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AGRICULTURAL PROGRESS IN OUR NATION'S PAST AND FUTURE

Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, before the Nebraska USDA Centennial Dinner, October 17, 1962.

I am glad to have the opportunity of joining you during this centennial celebration. Tonight we're recognizing 100 years of agricultural progress, initiated by three Acts of Congress passed in 1862 -- the Acts creating the U. S. Department of Agriculture and the Land-Grant College System and the Homestead Act.

I can't think of a better spot to observe this particular centennial than right here in Nebraska. While the State did not enter the Union until 1867, five years after the passage of the three memorable pieces of legislation, Nebraska has been part of this century of progress from the beginning.

It was here in Nebraska that David Freeman filed the first claim under the Homestead Act and launched the opening of the West. His original homestead is now a National monument in recognition of the contribution this movement made to the development of the Nation.

Nebraska gave us the third Secretary of Agriculture in J. Sterling Morton, adopted from his native State of New York. Mr. Morton was appointed by President Cleveland in 1893, following the six Commissioners and the first two Secretaries of Agriculture.

This State has made a significant and continuing contribution to the development of agriculture from those early days on through to the present, both in the day-to-day operation of your farms and ranches and in the outstanding research here in the Agricultural Experiment Station.

In this centennial year, when we take stock of agriculture, we are in reality evaluating the progress of an entire Nation. For man must spend as much time as it takes to provide the food, clothing, and shelter he needs. Until that is done, he has no time for any other pursuit. Until agriculture is producing enough food, the rest of the Nation cannot develop its full potential. In that sense, in today's America -- our industries, our comfortable way of life, our high standards of living -- the keystone is the development of agriculture during the past 100 years.

In 1862, sixty out of every 100 workers were laboring on farms to produce the food and fiber for the Nation. One farm worker was feeding himself and five other people.

Today, in 1962, one farm worker feeds himself and 26 other people, and only 8 out of every 100 workers are employed on farms. The other 92 can work elsewhere to provide the goods and services that advance our civilization.



They're working in manufacturing, providing the goods for today's living . . . the cars and planes, the stoves and refrigerators -- the necessities and luxuries that make up our way of life. They are engaged in wholesale and retail trade, working in stores, markets, and warehouses -- bringing the goods necessary for our daily living within easy reach. Some of them are airplane pilots, truck drivers, newspaper reporters, and telephone repair men. Some are in construction work, building homes, office buildings, bridges, churches, and schools. Others are in service work -- in hospitals, hotels, and laundries.

These are the ways people are working today in this country because farmers are efficient enough to produce all the food and fiber we need with only 8 percent of the working people.

Because farming in the United States is efficient, American consumers spend a smaller portion of their income on food than any other people in the world. In western Europe, food costs take 30 to 45 percent. In the United States, we are spending about 20 percent of our incomes on food.

In short, a productive and efficient agriculture has provided this Nation with the greatest abundance and variety of the highest quality food at the lowest relative cost in the history of the world.

The abundance has, at times, amounted to a surplus in a few major commodities, comprising from 5 to 8 percent of the total agricultural production in this country. These surpluses have created real problems, some of which are still not solved. But by far the greater part of our agricultural production -- about 92 to 95 percent -- has been required to maintain the growing strength and vitality of the Nation, in times of peace and war.

Part of the efficiency and productivity of our agriculture has been made possible by our rich natural resources and generally advantageous climate. Part of it is the result of the hard work and ingenuity of our people. But most of the farming efficiency in this country today is based on the results of research.

Increases in yields of plant and animal products have come from the combined effects of advances in mechanization and technology -- advances in genetics, physiology, and plant and animal nutrition. Higher yielding plant varieties have been developed. Animals have been bred with a natural capacity for more efficient production. Methods have been found to control or eradicate many of the more costly diseases and pests that plague both plants and animals. Farm machinery has been tailored to fit many of the specific requirements of agricultural production.

The research that developed this knowledge and technology has been a bargain. The bill for all agricultural research in the last 100 years -- paid by State and Federal Governments and by industry -- is less than \$6 billion.

That figure takes on significance when you realize that if farmers today used the methods of 1940 -- that's just a little over twenty years ago -- it would cost an extra \$13 billion a year to produce food and fiber for the Nation. That amounts to more than \$5 a week for each family's bill for farm products. So in terms of value received, our agricultural research has truly paid rich dividends to our economy.



It is only logical to assume that research will continue to point the direction of our developing agriculture in the future. Actually, while it is true we have come a long way from the days of a man, a mule, and a plow, there is still much to be done to bring farm production to peak efficiency.

Too many farming operations have not yet been mechanized and still require too much hand labor and too many man hours. We have not yet found effective ways to control the agricultural pests that add \$10 billion every year to the cost of farm production in this country. Agricultural production is meeting our national requirements in quality and quantity, but the individual farmer is not competing successfully with the rest of the economy in income.

In other words, we have not yet solved all the farm problems facing us today, and the problems in the years ahead are quite likely to be even more complex.

If current trends continue, we can logically expect certain inevitable results in at least the immediate future. For instance, we can expect greater specialization in agricultural production -- specialization in individual farms and by areas. The family-operated farm will continue to grow larger and more complex. Each farming unit will require increased capital investments. All such developments will create more complicated problems in management for the farmers.

There will be production problems as well. For example, we already know we need new and better types of pest control. At the present time, chemical pesticides are an integral part of American agriculture. It is apparent that they will continue to be an important element in our food production throughout the foreseeable future.

The American public has actually made that decision. Consumers have come to expect the variety of fruits and vegetables that can be produced in commercial quantities only with the use of pesticides and other chemicals. Family shoppers will not accept the quality of fruit produced in orchards not treated with chemicals.

But if consumers are interested in the benefits that chemicals help to provide in our agriculture, they are also concerned about the chemical residues that might remain on food products. Farm producers, the chemical industry, and the regulating agencies involved are facing this concern today. We are certain to continue facing it in the future.

We are searching now for new types of chemicals that are effective against agricultural pests but not harmful to man and other warm-blooded animals . . . or that are effective during the life of a planted crop, but lose toxicity by harvest time . . . We are looking for biological controls that will be effective against pests without the danger of residues in food or create any possible hazard to fish, birds, or other wildlife. You are probably familiar with the use of radiation to control and eradicate the screwworm fly in the Southeast and the current program in the Southwest. In the future we can expect to expand the use of similar methods against other pests in other areas.

Agricultural research -- some of which is cooperative with the Nebraska Experiment Station -- is geared toward finding the most important answers to these problems of today and tomorrow as quickly as possible. For example, the research program of the United States Department of Agriculture is putting the greatest emphasis on four major areas:



1. Adjustments to achieve better management of our abundance; and wiser use of soil, water, and forest resources.
2. Improvements that will reduce the cost of farm production; make those costs more predictable; and provide greater protection for agriculture against the increasing hazards of plant and animal diseases, insects, weeds, and weather.
3. New uses for farm products, new crops for industrial and other needs, domestic and foreign markets, and more efficient marketing methods.
4. Better quality in agricultural products and improved consumer use of food and fiber.

In putting this broad program to work, we are using the new technology that has been developing in all the sciences during the last 10 . . . 15 . . . 20 years. Today, with the high-speed electronic computers, the electron microscope, and other technological progress in research tools, we can attempt studies on a broad scale that scientists ten years ago couldn't even consider. We can see things that have never been seen before. We can analyze data in a matter of hours that would have taken an impossible number of years without these new tools.

We can take advantage of complex electrical systems such as we are using today in our soil and water research. We are now using an analogue computer that simulates an entire watershed system to find out exactly what happens when water flows through the soil.

On normally vegetative land, 70 percent of the available water supply is lost through evapotranspiration. The remaining 30 percent is all we have left for the uses of man, including agriculture, industry, and normal urban uses. Each year the competition for this water becomes keener and more serious. It is vitally important for our future well-being that we make use of any new technique and material that can help us to find ways to save more of the water that is now being lost.

One of the ways in which we're approaching the problem in dry areas is through attempts to solidify the soil in areas of run-off. It is a process of "water-proofing" the soil to increase run-off into reservoirs and reduce soil erosion during the process.

This is an example of applied research to solve immediate and pressing problems. It is the most urgent and familiar part of our continuing research program -- in the Department and in the Experiment Stations in the various States. But also of vital importance to the solution of agricultural problems in the future is the basic research being conducted today in our various institutions -- research that is manipulating germ plasm and digging deeper into the character of the living cell. This is truly our hope for the future, because as man understands more about the world around him, he expands his power to extend nature's potential for his own benefit.

For example, basic studies of plant genes conducted here at the University of Nebraska, in cooperation with the Agricultural Research Service, have resulted in a major breakthrough in the development of hybrid wheat. It was announced just last week. The gene that will restore fertility in male-sterile wheat was found in plants growing in nurseries here at the University College of Agriculture. This fertility restorer has been the "missing link" in efforts to produce



hybrid wheat. Therefore, this research finding in plant genes may well prove to be of tremendous practical significance.

Turning to animal genes, the scientists in one of the ARS Pioneering Laboratories are studying blood antigens. They're trying to learn how genes and hormones in the blood act together to form antigens. They are trying to induce mutation of red cell antigens in pigeons, and investigating the chemical constitution of antibodies.

Once we know more exactly what makes up antibodies, we may be able to synthesize them and use them purposefully and specifically to combat diseases such as foot-and-mouth disease, hog cholera, or even human diseases.

Other scientists in the Agricultural Research Service are studying the seed proteins. They're trying to find out what functions the various seed proteins perform. In order to approach that problem, they are not studying the isolated proteins in the static sense. They are looking at them as component parts of the seed. Why are the various proteins present?

For instance, the seed itself is in a dormant state. There has been tremendous activity to bring the seed to maturity. And there is great activity again when it germinates and starts functioning. But what makes the seed come to a halt, and what part do the proteins play in creating the quiescence and holding the seed in that state? What machinery starts the action again?

In asking some of these "how" and "why" questions, the scientists, with the aid of brand new techniques, were able to purify a specific protein in the peanut that had never before been identified. We don't know for sure what its function is, but the fact that it disappears within three to five days after germination leads to the speculation that it is involved in the germination process.

We are continuing to investigate this and the various other proteins so that we can know more about their influence on plant growth -- and more about seeds as an important source of protein for human nutrition and industrial uses.

In still another field, our scientists are working on the effect of light on plant growth and development. These are the studies that identified phytochrome, the pigment that responds to the presence and absence of light and controls plant function from seed germination to flowering. It is intriguing to the imagination to consider the possibilities of man's complete control of plant growth and development by controlling the exposure to darkness and light.

These are only a few examples of the areas in which we will need new knowledge. There are many others -- in farm machinery to meet new requirements -- in human nutrition to sustain the health and vitality of our people -- in marketing and finding new uses for farm products.

Research must continue and redouble the effort to find this new knowledge. If we stand still, agricultural progress automatically loses ground in a rapidly changing world. It is particularly important not to fall behind right now, in the light of population growth estimates. Economists now predict that our population will double in the next 40 to 50 years. In addition, we have a responsibility in the world community to help find ways to supply food to the hungry peoples of other countries.



These research needs are already putting a strain on available scientific manpower. The scarcity of scientists is likely to become even more apparent in the future. Research and educational institutions concerned with agriculture must take every opportunity to attract the young minds of the country to agricultural research . . . Encourage young people to study agriculture and related sciences in high school and college . . . through graduate school. From these young students will come the brainpower of the future -- the brainpower we need for agriculture to continue sustaining the strength and vitality of the Nation.

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C & R-PREP.

EFFECTS OF AIR POLLUTION ON CROPS AND LIVESTOCK

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Talk by Dr. H. A. Rodenhiser, Deputy Administrator for Farm Research, Agricultural Research Service, U. S. Department of Agriculture, before Panel D, "Agricultural, Natural Resource and Economic Considerations," National Conference on Air Pollution, Washington, D. C., December 11, 1962.

C & R-ASF

It's a pleasure, indeed, to take part in this panel today.

I am honored to share a place on the program with some of the distinguished pioneers in the field of air-pollution research. Much of what I have to say reflects their contributions to our knowledge.

Then, too, I am glad to have this opportunity to focus attention on what I believe is an increasingly serious hazard to the Nation's agriculture.

We already know that air pollution is costly to farmers. There's good reason to suspect that it's even more costly than we know. And every indication is that it's going to get worse as this country continues to grow.

The point I want to make is that anything that increases farmers' costs is important to you and me and 187 million other Americans. Our highly developed economy is based on our remarkably efficient agriculture.

Air pollution is not a new problem in agriculture. But we are just beginning to appreciate the full significance of this threat. Most of the old pollutants are still causing some trouble, and we have new ones that promise to challenge our finest scientific brains.

Let's look at today's major problems.

One of the oldest known pollutants of rural air is sulfur dioxide. Its effects on plants have been recognized for well on to a hundred years.

Fortunately, sulfur dioxide is no longer killing vegetation on as grand a scale as it was early in this century around the great copper smelters at Anaconda, Montana, and Ducktown, Tennessee. Their fumes drifted for miles and left gullied deserts -- bare to the grass roots. Control measures have now done away with such extreme damage.

And yet, we still find some crops and trees being killed and others being marked by sulfur dioxide from a host of sources all over the country. These include power, chemical, and steel plants, as well as smelters.

Of a wide variety of plants damaged by sulfur dioxide, alfalfa, barley, cotton and coniferous trees are the most sensitive.

This gas may still be a serious factor in some forest diseases. Recent work on the cause of post-emergence acute tipburn in Tennessee indicates that sulfur dioxide may be involved as a possible factor in this disease.

Another important nationwide air-pollution problem is the damage to vegetation and livestock from fluorides. These are thrown off in the course of heating ores, clays, or fluxes containing fluorine to extremely high temperatures.

The fluoride sources that caused trouble with cattle 15 to 20 years ago are now reasonably well under control. Many of these steel mills, ceramic works, aluminum reduction plants, and superphosphate factories have installed air-cleansing devices on their flues and furnaces.

Even so, the number of fluoride sources has increased, and we see the effects in several places.

Ponderosa pine has been extensively damaged by fluorides from an aluminum plant in Spokane County, Washington. Citrus trees are adversely affected in California. Many other plants are sensitive -- particularly gladiolus, apricot, sweetpotato, grape, and prune.

But even more troublesome is the fact that some of our common forage plants are fairly resistant to fluoride injury. Alfalfa, for example, may go on storing atmospheric fluoride and still look perfectly normal -- yet, it may contain enough of this toxicant to produce a serious case of fluorosis in animals that eat the hay.

A serious new air-pollution threat has developed in the last few decades. This new pollutant -- photochemical smog -- is no longer a problem of the Los Angeles Basin alone. It's causing significant crop losses along the Northeast seaboard, and its markings have now been found in practically every metropolitan area from coast to coast.

Whereas fluorides and sulfur dioxide are usually traceable to a few large industrial plants, smog comes from millions of sources throughout our highly industrialized and mechanized society.

In this dirty urban air are many waste materials. Among them we find nitrogen oxides -- produced wherever hot combustion takes place, such as open fires, home furnaces, and automobiles. And we also find incompletely burned hydrocarbons -- thrown off from all types of combustion . . . at least 400 different hydrocarbons are found in gasoline alone.

These contaminants are often entrapped close to the ground by an inversion layer of warm air -- a typical weather pattern in the Los Angeles Basin as well as a vast area of the Northeast.

When hydrocarbons and nitrogen oxides mix in the atmosphere in the presence of sunlight's ultraviolet rays, some complex and delicately balanced reactions take place. Here is the source of two oxidizing substances that cause most of the so-called smog damage to plants.

One of these oxidants is ozone, which primarily injures the upper surface of plant leaves. Some ozone occurs naturally in the atmosphere -- but ordinarily not in harmful amounts.

The other oxidant is peroxyacetyl nitrate, or PAN, which causes a silvering, glazing, or bronzing on the lower surface of the leaves.

It takes only fractions of a part per million of either of these oxidants to damage some vegetation. This may mean not only marking the plants but also reducing photosynthesis, increasing respiration, inducing early leaf drop, slowing growth, and lowering yield.

Ozone has now been definitely identified as the cause of weather fleck, a disorder that injures the leaves of tobacco all the way from Florida to Canada. In New Jersey, ozone has damaged spinach extensively -- indeed, it can no longer be grown in some areas. Grape, beans, and a number of ornamentals have been injured, and the list of damaged crops continues to lengthen.

The so-called mystery disease of eastern white pine -- emergence tipburn -- was recently attributed to ozone. This blight kills and damages trees wherever eastern white pine grows. Ozone also appears to cause X-disease, a chlorotic decline striking thousands of acres of ponderosa pine in California's San Bernardino Range.

While ozone appears to be responsible for most of the smog damage in the East, PAN is considerably more destructive in Southern California. I understand the threat is beginning to spread into the San Joaquin Valley, where five of the Nation's ten leading farm counties are located. PAN injury is seen on many field and horticultural crops.

As this brief review indicates, a number of air pollutants are damaging the crops, forests, and livestock of this country. How well are we prepared to deal with these toxicants? How much do we know about them?

In the case of livestock, our main concerns have been an old problem of arsenic poison from smelters . . . and the ever-present fluorides. We are well aware of the lethal effects when animals ingest forage plants that absorb these pollutants.

Beyond this point, however, we have little to go on. There is some reason to believe that such pollutants could derange the growth processes of plants and thus reduce the content of desired feed nutrients or cause the formation of toxic constituents. But this area has barely been explored.

At present, we have no solid evidence that farm animals are significantly injured by such pollutants as sulfur dioxide or oxidants. Very little work has been done on toxicity levels for livestock.

And yet, medical research reveals that these toxicants do present a hazard to human health. Absorption and circulation of such gaseous compounds can damage tissues beyond the lungs -- for example, enzyme and nervous systems, blood hemoglobin, and organs such as the liver and kidneys.

In view of the dangers to man, it seems reasonable to think that there must be many areas where livestock are endangered. Substantial losses could occur in borderline zones where the effects don't look spectacular -- yet pull down performance in terms of reproduction, growth, and output of milk, eggs, and wool.

Turning to plants, we find that we know a little more about the effects of air pollution. At least, the visible effects of most of the common toxicants are fairly well known. A competent observer in the field usually has no trouble identifying the necrotic lesions that sulfur dioxide or fluorides induce on plant leaves. And the injury patterns produced by ozone and PAN are not difficult to distinguish. Workers also have considerable knowledge of the breakdown that takes place within the cell structure of the leaves.

But we are not so well off when it comes to the possible effects of air pollutants on such matters as the growth, yield, nutritional quality, and survival of plants. We have some leads, of course. We know that severe leaf injuries by pollutants will affect growth -- and perhaps survival in the case of trees, which take repeated exposures year after year. We have reasonable evidence that oxidants or fluorides -- even at levels that don't mark the foliage -- may significantly reduce growth rate and fruit quality in some cases.

But this area is complicated by two extremely important influences: genetics and environment. As for genetics, we expect different species to respond differently to air pollution, but the variations within species are often just as great. Workers have seen the effects of many environmental factors, including rainfall, temperature, wind, nutrition, soil moisture, and management practices. For example, there are significant differences in the injury threshold from one area to another -- plants in the humid East are damaged by much less oxidant than those in the arid West.

On top of all this, the pollutants themselves interact with each other in the atmosphere and also interfere with each other's effects within the plant.

You can see that we have explored the effects of air pollution on crops, but so far we haven't pushed in deeply on a broad front.

It's not surprising -- considering how little we know about these effects -- that we can't say exactly how much the losses run in this country.

Of course, the answer is easy in the case of a crop like romaine lettuce, which sells on the basis of appearance. Ozone markings on the outer leaves could make the crop a total loss.

The question is more difficult when a crop like alfalfa is injured by sulfur dioxide. We now know that yield is reduced in proportion to the area of leaf destroyed -- whether it's lost by clipping or air pollution.

But we face a far more complicated problem in determining PAN damage to a citrus tree. As yet, no one can say how much yield or grade of fruit will be affected by a given degree of leaf injury. Growth is reduced in severe cases, but we don't know how much this will affect the crops that follow.

And the answer is still harder to find in the case of fluoride damage to pine trees. Here we are dealing with a crop that may not be ready to harvest for another 40 or 50 years.

Although we don't have a good measure of the total national loss from air pollution, figures have been published for some localities. In Southern California, for example, losses of vegetation due to oxidants are thought to be around 10 million dollars a year. This includes only the readily demonstrated losses of vegetable crops down-graded because of markings or left unpicked in the field.

If we try to add up all the known losses around the country . . . make some reasonable estimates for the suspected losses due to reduced yield and quality . . . and include a guess for losses in ornamentals -- the figure is in the hundreds of millions of dollars a year.

It's apparent that agriculture has a vital interest in air pollution -- and a responsibility for research in this field.

Some very good work is already being done. The pioneering research of the University of California and the Public Health Service immediately comes to mind. Several other State experiment stations, including those in Tennessee, New Jersey, and Connecticut, have studies under way. Industry and private institutions are conducting and supporting research.

Right here, I want to make it clear that I am not satisfied with the meager efforts in this field by the U. S. Department of Agriculture. But those of us who are responsible for the Department's research do recognize the importance of this problem. And I am more hopeful now than I have been in several years that we will eventually obtain support at the level we feel is justified.

All the work now under way -- good as it is -- adds up to little more than a beginning on the problem of air pollution in agriculture.

I feel that the greatest need -- in crops, forests, and livestock -- is basic research. We need to determine the mechanism of action of pollutants and their effect on metabolic processes. Such work is essential if we are to evaluate the effects on growth, development, and survival of plants and animals, as well as the quality and use of the products.

An example of the sort of work I have in mind is the project the University of California at Riverside is now carrying out under contract with USDA to determine the effects of air pollutants on carbohydrate metabolism in citrus. We hope to learn here for the first time how pollutants influence the food-making process and enzyme activity.

Basic studies should be conducted with plants and animals to discover how their physiological response to toxicants is related to the influences of genetics and environment. This basic work should include the effects of intermittent exposures of forest trees to low levels of air pollutants over a long period.

There's also need for research on the nature of the pollutants . . . on levels of toxicity . . . on how the nutrients and quality of feed are affected. We should find out the extent to which agriculture itself contributes to air pollution -- as in the burning of straw and stubble. Adequate surveys must be conducted to assess the damage to crops and livestock. Additional work is needed on biological indicator plants that reveal the nature as well as the presence of air pollutants.

From investigations such as I have suggested, we should gain the knowledge that will enable us to deal with air pollution in agriculture. Let me suggest some of the possibilities.

One is the development of protective management practices. For example, we might be able to control weather fleck by applying antioxidants to tobacco when an ozone buildup is expected. Workers in New Jersey see the prospect of a forecasting system to warn farmers, greenhouse operators, and home owners of air-pollution threats. The Weather Bureau now has a pilot-type forecasting service for the eastern half of the country.

A second possibility is the development of resistant varieties and strains. Breeders recognize that plants vary in susceptibility, and this knowledge is already being put to use. In the Connecticut Valley, for instance, resistant varieties of tobacco are greatly minimizing damage from weather fleck.

A third possibility -- one that I regard as a matter of great urgency -- is development of air-quality standards. It is quite evident from the recent buildup of pollution in California and along the East Coast that standards have to be established. And in many cases, the limit of a standard is going to depend on the vegetation desired for an area -- whether this be for economic agriculture . . . or the maintenance of a cover to prevent erosion . . . or the growth of ornamentals for esthetic purposes.

A fourth possibility for using new knowledge of agricultural air pollution is the development of better Federal consulting services to States and local communities. We should be in far stronger position than we are to furnish advice on such matters as gauging the effects of pollutants, conducting surveys, formulating air-quality standards, and devising field control practices.

I recognize that finding the answers we need on air pollution will not be simple, quick, or cheap.

For one thing, it will take improved research tools. We must have better instrumentation for continuous monitoring of pollutants at low levels. Some of our present processes are too tedious and expensive, and there's not enough equipment available.

Even more important than tools, however, is well-trained personnel. Exploration of this area is complex, and it calls for competent workers in many disciplines -- pathologists, physiologists, veterinarians, nutritionists, agronomists, horticulturists, foresters, meteorologists, engineers, and analytical, physical, and biological chemists. It won't be easy to find enough of the kind of people we need to do this job.

So we will be up against some formidable obstacles as we move ahead against agricultural air pollution. But we must not allow these obstacles to keep us from launching a full-scale research effort as soon as possible. The kind of work that's needed here will take time.

I am convinced that air pollution is not so much today's problem as it is tomorrow's. We may well have 14 percent more people and 26 percent more automobiles in this country by 1970. There's every reason to believe that the trend toward greater urbanization and greater mixing of agricultural and industrial areas will increase the total impact of air pollution on the Nation's farms.

We must face the fact that our air -- like our soil and water -- is limited. It, too, will have to be conserved.

I believe it's vital to see that air-pollution research in the field of agriculture moves ahead . . . now . . . before we get even further behind.

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TEAMWORK IN AGRICULTURAL RESEARCH

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20, 1963  
Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, at the first annual scientific workshop of the Animal Disease and Parasite Research Division at Ames, Iowa, May 20, 1963.

It is a pleasure to speak to a family group such as we have here. I believe we are all a part of the Agricultural Research Service either by choice or by marriage.

The wives of scientists, I find, absorb an amazing fund of knowledge about their husbands' work. Therefore, I feel that I am addressing a congregation of experts.

Sometimes our everyday routines loom so large that we lose sight of what our work, and that of our fellow scientists in ARS, mean to agriculture and America.

To sustain life, man -- and particularly woman -- must spend whatever time and effort is required to provide the necessary food, clothing, and shelter. Until that is done, nobody has time for any other pursuit. Here in the United States, our increasingly efficient agriculture has freed the vast majority of people for productive work of other kinds -- work which has developed a highly industrial economy and a comfortable standard of living.

I need not tell you the part research has played in making American agriculture the most efficient and productive in the world. Though ARS research finds application mostly on the Nation's farms, every citizen feels its impact.

It extends into every supermarket, helping to fill America's market basket with an abundance of nutritious, safe, and reasonably priced foods. Research adds work-free hours to a woman's day by providing convenience foods, wash-and-wear fabrics, and efficient household organization and management.

In order that such benefits may continue and multiply, research must flourish. A flow of original and useful ideas comes primarily from trained and talented scientists working in an environment of free scientific inquiry.

ARS needs to attract and hold imaginative scientists. It now recognizes more concretely than ever before the scientist's personal need to advance financially on the basis of merit. Today, an ARS scientist has an opportunity to receive compensation fully equal to that of persons in the agency's top administrative posts while continuing to pursue individual research.

Our Service's plan for more adequate recognition of outstanding research ability has been adopted by the Civil Service Commission for use, with minor modifications, throughout the Federal government. Thus originality and creativity, the qualities that add most to the stature of a well-trained scientist, are being more practically evaluated and rewarded.

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Our research investments are something like our personal investments. We've all seen opportunities go by, during our lifetimes, to pick up at a bargain many a promising investment that would have paid off handsomely in the future. It may have been a piece of real estate, or an underpriced stock, or a part in a growing business.

The trouble was, we were so busy making ends meet that most of us had to let such opportunities slip by.

Research is somewhat like that. In most of our history, we've been so busy helping the farmer solve practical problems we've had little manpower or funds for basic research -- the research that eventually yields the greatest rewards. Now we need to build up a new reserve of fundamental knowledge of nature's why and how.

From the strictly practical viewpoint, basic research pays its way many times over. Any one of a number of discoveries in animal health, for example, has saved our economy enough to pay for all the research costs since 1894, when such Federal investigations began.

Basic research in ARS has been increased in a dozen years from 7 percent to nearly 35 percent of our total research effort. This is almost three times the proportion devoted to basic research in all Federal research and development. Eventually, we look forward to dividing every ARS research dollar equally between basic and applied research.

To supplement the basic work carried on in every research Division, we've also established 16 pioneering research groups in ARS. They are staffed by selected scientists of proved capacity to investigate the very limits of scientific understanding. These pioneering laboratories are unique in two respects: they are devoted solely to the development of new scientific laws and principles without concern for the solution of immediate practical problems; and their scientists are largely free of supervisory or administrative responsibilities.

Whether our research is basic or applied, the team approach, cooperative between disciplines and divisions, is becoming more and more essential. Seldom is an agricultural problem solely a problem in chemistry, or in engineering, or in virology. Its complexity often demands the concentrated efforts of specialists in many fields.

Science has, in fact, become so complex that on most long-range research we no longer ask, "Should we have a team approach?" but "How can we make multidisciplinary research most effective here?"

Next to capable scientists, facilities and equipment are the first essential. The present trend in State and Federal research is toward fewer but larger laboratories better equipped and staffed than small ones could afford to be. There, administrative "housekeeping" duties can be largely taken off the hands of scientists. Reference libraries and scientists in other disciplines are available. These opportunities are generally best at universities and State agricultural experiment stations.

Next, an atmosphere must be created that promotes free exchange of ideas. Seminars, work conferences, and occasional task forces can foster friendships and encourage mutual respect among members of the scientific community. Such meetings as the ADP workshop we are now attending, with its informal swapping of ideas, stimulate interest in working together to solve mutual scientific and related problems.

Scientists have of necessity been stationed, at times, at small laboratories and field locations where only two or three people in the community understood or appreciated their work and could discuss it. In the scientific community, however, the talk that goes on can whet and clarify one's own thinking while opening the mind to other disciplines and points of view.

Team research is at work at ARS stations in all our 50 States. Here at the National Animal Disease Laboratory, the entire effort is geared to this approach, which should intensify and expand as the various programs get further under way.

At Ithaca, New York, scientists in soil and water conservation, animal husbandry, and animal disease and parasite research are jointly attacking the complicated interrelationships between plants, soil, and animal nutrition.

At Athens, Georgia, the work at the new Southeast Poultry Research Laboratory will be cooperative between three Farm Research Divisions -- Animal Disease and Parasite Research, Animal Husbandry, and Agricultural Engineering. For the first time, a team will study intensively the combined effects of poultry disease, heredity, and environment.

Animal health scientists and entomologists cooperate on much research -- for example, at Denver, Colorado, and at Beltsville, Maryland, on diseases and their arthropod vectors; and at Kerrville, Texas, on effectiveness, safety, and toxicity of pesticides.

Although the importance of multidisciplinary research is readily recognized, it can never be a realistic substitute for individual effort and initiative. It should and must enhance and complement them. We believe that within the framework of coordinated team research the imaginative individual can still find the freedom conducive to uninhibited scientific inquiry.

Much of the overall ARS research program outside the Farm Research Divisions is of great interest in animal husbandry and health. For example, ARS human nutritionists are investigating the role of fats in our diet. Utilization research scientists are finding new uses for inedible animal fats in such things as plastics, waterbase paints, floor wax, and livestock feeds, and are developing a dry whole milk which shows promise for alleviating our dairy surplus problems.

It is with farm research, however, that I am most familiar. It is the oldest and most widely recognized activity of ARS. It ranges from tropical research in Puerto Rico, the Virgin Islands, and Hawaii to sub-arctic research in Alaska.

This year, our budget of \$58,334,500 has been devoted to research by the six Farm Research Divisions at 212 locations throughout the United States and abroad. More than half these locations -- 130 -- are at Land-Grant colleges and their substations. Our professional scientists number more than 2,000.

Our work is carried out in cooperation with the States, with industry, and with the governments of foreign countries.

ARS supports research at State experiment stations through both contracts and cooperative agreements. In contrast to most of the executive departments of government, we have a strong in-house capability for research, and only about 1 percent of our total budget goes into contract research.

In our extensive program of cooperation with the States, ARS is usually concerned with broad regional or national interests; the State experiment station is usually interested in needs of the State and the region. The phenomenal spread of hybrid corn in the United States is largely the result of a cooperative breeding program between several States and the USDA.

In addition to our Stateside responsibilities for research beneficial to American agriculture, we have responsibilities which involve several farm research stations abroad. For example, research on foot-and-mouth disease is going on in the Netherlands; African swine fever is being studied in East Africa. Explorations for insects that will devour weeds are being made in the Mediterranean region and in Morocco; other foreign explorations for parasites of agricultural pests are headquartered in France. Research on insects, cotton breeding, and wheat seed increase is being conducted in Mexico.

Our other foreign research is conducted within the authority of Public Law 480. Under its provisions, research is financed with local currencies derived from the overseas sale of farm commodities which we produce in abundance. This research extends and supplements many types of work we are doing in the U. S.

Judging by progress made so far, these P.L. 480 projects will prove very valuable to both the countries involved and to the U. S. They will also enhance rapport with foreign scientists, and increase mutual respect, understanding, and communication.

There are obvious advantages to be derived from on-the-spot studies of foreign insects and diseases that ravage other countries and threaten our own. Under P.L. 480 grants, the Animal Disease and Parasite Research Division sponsors some 20 research projects on various aspects of animal diseases and parasites in 8 foreign countries. The dozen or so diseases may be as familiar as swine erysipelas and chronic respiratory diseases in chickens, or as exotic as African swine fever or babesiosis of cattle. Emphasis given to parasites includes studies on horse bots in Turkey and certain leeches in Israel.

In this country, farm research is concerned with conserving soil and water resources, producing quality agricultural products efficiently, and protecting crops and livestock from the many hazards that beset them.

Probably most basic to life is conservation of our soil and water resources. In this widespread and diverse Nation, our conservation engineers located in many parts of the country may be figuring out how to irrigate a desert, drain a swamp, prevent a dust bowl from forming, and stem a flood -- all on the same day. Other scientists are exploring the fundamental relationships of soils, water, plants, and animals.

Our agricultural engineers devise concepts and systems which utilize men, materials, and energy in the most efficient possible combinations. To further mechanize crop harvesting, they've developed equipment to harvest several types of fruit at the rate of 30 to 50 trees an hour. To reduce labor in livestock production, they have perfected an automated feeding system which carries feed from bin to feeders as easily as you can pipe running water.

Scientists of the Crops Research Division have played a leading role and worked closely with the various States in developing information which has led to a change in selection of plants that farmers grow in their fields. These scientists have supplied new germ plasm and adapted foreign crops to our climate and methods of farming. They have fixed resistance to various diseases and insect pests in established crops, and tailored many crops to fit machine operations on the farm.

The Animal Husbandry Research Division is helping farmers to increase the efficiency with which feed is converted into meat, poultry, milk, and eggs. Research and critical evaluation of breeding and performance testing have resulted in improved milk producers, meat-type hogs, lean, tender beef, and meaty broilers. We are producing over 35 percent more beef per cow today than we were 25 years ago, nearly 25 percent more pork per sow, over 60 percent more milk per cow, and over 70 percent more eggs per hen.

The Animal Disease and Parasite Research Division develops defenses for the health of our \$19-billion livestock, dairy, and poultry industry. You might call the trio of its principal laboratories the national institutes of animal health: NADL here at Ames for the study of domestic livestock diseases, our Plum Island Animal Disease Laboratory, off the coast of Long Island, New York, for foreign disease research, and the Parasitological Research Laboratory at Beltsville, Maryland.

The prospect is promising for biological control of animal parasites through use of vaccines, special management practices, and sanitation. No chemical residues on meat, or resistant strains of pests, could result from such an approach.

Studies on weed control, nematodes, and plant diseases in the Crops Research Division and the work of the Entomology Research Division comprise our other research defenses against the natural enemies of agriculture.

Entomologists continue to work on conventional chemical insecticides -- still the mainstay of agriculture's defense against insects. But our long concern with residues, together with the growing resistance of insects to chemicals, has led to a steady shift in emphasis over the years. We now devote about two-thirds of our entomological research to biological controls, specific chemical techniques, and basic explorations of the life processes of insects.

For example, from years of basic research has come a new defensive weapon against cabbage loopers. These insects damage more than a dozen different vegetables, field crops, and flowers. From 10 diseased loopers, insect pathologists can produce a pinch of grayish powder that contains enough virus particles to infect an acre of land with a disease deadly only to cabbage loopers.

Such research as this is often put to work in ARS regulatory programs -- programs that actively protect our crops, livestock, and food supply from diseases and pests.

Animal and plant quarantine inspectors stand guard at our ports and borders to protect against foreign pests and diseases of crops and livestock. They also help to keep our agricultural exports pest-free, and insure the purity and potency of veterinary biologics.

If foreign pests evade these guards and enter this country, the Plant Pest Control Division and the Animal Disease Eradication Division may launch cooperative Federal-State control or eradication programs against the invaders. It is usually better to eradicate such pests than to learn to live with them, and early detection makes this possible.

The Pesticides Regulation Division protects the public against fraudulent, ineffective, and unsafe chemicals used against farm, household, and human pests.

The Meat Inspection Division safeguards the purity and wholesomeness of our domestic, imported, and exported meats and meat products.

These six regulatory Divisions are both a proving ground and a showcase for much of the work conducted by the six Farm Research Divisions.

No pest eradication program can be effectively undertaken until research provides the tools. Sometimes we must launch new research in a hurry when a new pest or disease crosses our borders. However, in most cases regulatory work is best served by long-term basic research.

For example, the sterile-male principle, developed through ARS research, has worldwide implications. It led to eradication of the screwworm fly in the southeastern United States. Continuous release of insects that have been made sterile by radiation or chemicals can stop reproduction in the entire natural population of an injurious insect species and eventually eliminate it.

Teamwork with regulatory workers benefits research. Control programs can eliminate the time lag before a new research finding is put to work. Also, research and regulatory workers can together translate laboratory results into wide-scale application. Difficulties arise here, just as the erection of a seven-story building from a blueprint runs into snags neither the architect nor the contractor could have foreseen. Through further research and laboratory testing, regulatory workers often refine and in some instances shorten eradication procedures as programs progress.

Here, as in all our cooperative work, research and regulatory workers need to understand each other's problems . . . to communicate and plan together effectively . . . and to recognize and respect each other's contributions.

We can be proud of the record and the teamwork between research and regulatory programs. Because of it, several plant pests and diseases have been eradicated from this country -- for example, the parlatoria date scale, citrus canker, the Mediterranean fruit fly, and the citrus blackfly. Other plant pests are well on their way to eradication. Still others are being held in check by programs that are buying time until research can come up with practical eradication tools.

The same close teamwork has controlled or eradicated many animal diseases. Each new testing technique for brucellosis detection has been a milestone in its eventual eradication. When vesicular exanthema broke out in U. S. hogs, research resources were concentrated early enough for regulatory workers to design an effective program that eradicated VE from this country.

Since the 1890's, research and regulatory scientists have worked together to provide this country with a healthy livestock industry. Scientists regard the discovery that ticks transmit Texas fever as one of the great chapters in biomedical history. It not only led to the eradication of this cattle killer from the United States, but also unlocked the door to the role of vectors in human diseases . . . malaria, yellow fever, bubonic plague and, in fact, all of the arthropod-borne diseases of man, animals, and plants.

In closing, I'd like to give the viewpoint of the Surgeon General of the U. S. Public Health Service on the close relationship between human and animal health. In a speech last month, Dr. Luther L. Terry pointed out that the veterinary medical profession originated the concept of disease eradication, pointing the way for elimination of some of man's oldest and deadliest enemies.

After citing eradication of contagious pleuropneumonia, glanders -- a major public health problem at the time of the first World War -- foot-and-mouth disease, and fowl plague, Dr. Terry went on: "Now bovine tuberculosis is gone from most parts of the United States, and you are confidently envisioning the eradication of brucellosis."

"Many advances in experimental surgery could not have been made without animal research," he stated. "The story of the blue baby and achievements along similar lines are all the results of cooperation (between physicians and veterinarians) in this area of animal experimentation. Now we are finding animals useful to evaluate genetics, susceptibility to environmental influences, nutrition, and aging."

He spoke of a swiftly increasing interdependence between medical and veterinary medical science for the future, and predicted that "the public health service, then as now, will look to veterinary science for leadership and partnership in our joint adventure."

I want to echo Dr. Terry's hopes for cooperation between all of us in public service. It should begin in our own laboratories with teamwork between fellow scientists. It can expand to include all who share our aim -- the harnessing of natural forces for the betterment of man.



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## REGIONAL RESEARCH

Nov. 13, 1963

Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, before the Association of State Universities and Land-Grant Colleges, Chicago, Ill., November 13, 1963.

I think of regional research in agriculture as a meeting place, a common ground of understanding, between State and Federal research. It probably requires more give and take from all of us than any other form of cooperative research.

Federal-State cooperation in regional research is primarily a development of this century. As we all realize, its concepts developed slowly.

Most of the concern of the U. S. Department of Agriculture has, of course, always been with problems of broad regional or national significance. Developments of the 1930's advanced such investigations. Provisions of the Bankhead-Jones Act in 1935 for new regional laboratories and expanded research, and the later establishment of our four utilization laboratories, launched the Department into broadened research on regional needs. In 1936, the chief of the Office of Experiment Stations was made Director of Research for the Department -- a step which promoted cooperation between USDA, the States, and other agencies in research planning and coordination.

In 1946, the Research and Marketing Act provided the first funds for a formal, continuing program of cooperative regional research, and gave increased emphasis to the development of policies and procedures for such research. Since then, a wealth of new knowledge has been compiled. Regional research has come far, and continuing cooperation assures a bright future.

As such research gains momentum, the U. S. Department of Agriculture and its Agricultural Research Service strive continually to fulfill their commitments and responsibilities. ARS scientists have worked on a large proportion of the regional projects, whose numbers have grown from 50, in 1947, to almost 200 now under way. Federal scientists conduct research on two-thirds of the regional projects and serve with all of the technical committees.

When Dr. Byron T. Shaw, Administrator of ARS, addressed your Association in 1958, he laid down principles for redirecting and concentrating ARS activities to speed the development of regional centers for research. These principles have since been restated and underscored by the Secretary of Agriculture.

For a few minutes I'd like to reverse our present involvement in five-year plans for the future. Let's look back at the progress ARS has made in applying the principles outlined five years ago.

Our first job, as Dr. Shaw saw it, was to determine the areas in which ARS could make its greatest contribution to solving problems of regional and national importance. Our second job was to examine our research activities at each location -- in each area -- and determine what our future course should be.

Our commitment to teamwork research -- the combined efforts of scientists in many disciplines -- lends breadth and depth both to the research attack and to the scientists' own development.

This approach has made for fewer and better "centers of excellence" in research. Top-flight scientists, in their increasingly sophisticated studies, require substantial back-stopping. Last year, the supporting staff and operating costs of each ARS scientist averaged almost \$26,000. Ideally, we believe it should be almost a third higher -- about \$33,500. A scientist's work may require world-wide explorations, electron microscopes, atomic energy materials, or industrial pilot plants, as well as the sub-professional and administrative assistance that is so often inadequate in small laboratories.

ARS has closed out many small, isolated field stations and moved the scientists to larger laboratories. Today, we have 221 field locations of farm research -- 41 fewer than we had in 1958. The reduction trend continues.

Dr. Shaw also said our research centers should be, to the greatest possible extent, a part of the State agricultural colleges and experiment stations.

In the past seven years, ARS has put more than \$34 million into construction of 32 large building projects -- now completed or in process. The cost of these laboratories, offices, and supporting buildings ranges from \$120,000 to the \$17 million that went into the National Animal Disease Laboratory at Ames. Of these 32 facilities, 27 are located near land-grant colleges or universities -- many on the campuses -- or near State agricultural experiment stations or substations. More than 89 percent of the \$34 million was spent here.

This record speaks for itself. Our plans for future facilities follow this policy.

However, there will always be a need, we believe, to locate some Federal research away from State facilities. Urban growth and rising costs of land pose problems. Campuses of the future must stretch to accommodate bulging student populations, and some research facilities may have to retreat.

We believe that both State and Federal facilities should be available for housing both State and Federal people engaged in cooperative research. Our progress in putting this principle to work has been slow. Up to now, ARS scientists have more often been guests than hosts to State scientists. The Department has about 2,300 employees working on college campuses and State-owned field stations and spends approximately \$20 million at these locations. As enlarged Federal facilities become available on campuses, we expect to have more State people sharing our laboratories in team research.

Joint planning is now going on for developing, from the earliest stages, the State and Federal facilities of the future. It should produce a network of publicly supported centers we can all be proud of. Only by appraising our own and each other's needs can we establish logical priorities and locate research where it can be done most efficiently.

Public Law 88-74 will assist the States in providing additional research facilities at experiment stations. We hope it may be a stimulus for acknowledging competence and providing for concentration of the research effort.

In our planning, we welcome the counsel of the USDA-State team the Secretary set up this year. It is appraising the needs for future research, and particularly the division of research efforts. In the light of this appraisal, it is reviewing the Department's long-range projections of needs for new or improved facilities. The team's help in establishing priorities for our building program, both at Beltsville and in the States, will coordinate the total research effort more closely.

Federal grants have helped to support a broad base for agricultural science and scientists for about three-quarters of a century. Research needs both institutional grants and grants to support talent where it exists. We in ARS are still new in administering this second type of grants, for basic research, but we feel that they can contribute greatly to the growth of individual scientists.

Results are beginning to come in from a third kind of Federal grant -- those made under Public Law 480 for research by foreign scientists. As you know, sales of surplus agricultural products abroad pay for this research. The studies must benefit the agriculture of the United States. Our first such grants were made five years ago; we now have more than 400 in force.

We are impressed with both the quality of this research and the caliber of these scientists. Among them are even a few Nobel prize winners.

P. L. 480 grants offer a unique opportunity to secure basic information on plants and animals, and on pests we do not want, from distant regions that may be similar to ours in geography or climate. Here we could profit from more joint planning, and we welcome your counsel on regional problems that would benefit from such research.

In developing jointly planned, cooperative research programs, administrators and scientists alike face complex questions. Has someone already done research that we are thinking about undertaking? How can we dovetail our research planning with studies already underway? How can we keep up to date in our fields? Only adequate compilation and retrieval of scientific information can answer these questions.

Several new developments, as well as continuing services, can help us to cope better with the rising tide of science information. I'd like to mention a few that may interest or involve us.

A Section of the American Association for the Advancement of Science is trying to develop a science newspaper on a broad national basis. As yet, it has no sponsor. The Section hopes to develop a sample copy of "The Daily Scientist" -- that's its proposed title -- for groups of scientists to criticize and evaluate.

As to scientific journals, nobody knows whether thousands are being published today, or hundreds of thousands. The Biological Serials Record Center at Washington, D. C., is attempting to provide a worldwide, comprehensive pool of information on all journals, periodicals, and other biological materials that are published serially.

The National Referral Center for Science and Technology -- just established at the Library of Congress -- is designed to put scientists and engineers in touch with all the country's information resources. The Center plans to issue a directory of such sources next March. This clearinghouse will act as a switching point for requests, referring the questioner to the best available centers or experts. That may mean your institution -- or you.

Particularly useful in the planning of research is the Science Information Exchange of the Smithsonian Institution. It's a clearinghouse for information on current research actually in progress. Both government and non-government agencies participate. The Exchange has records on some 40,000 projects currently active in the life sciences, and about 20,000 in the physical sciences.

Information on ARS research has always been available to State people. However, the interchange of such information will be elaborated and improved when both State stations and our Central Project Office have cards on each other's projects on file. Cards describing the 3,200 ARS research projects are being printed for distribution next year. In the near future, there should be complete exchange of information on research now in progress.

The multiple-use reports of progress that the Department now puts out annually are available to others interested in research planning. They combine two former reports, and are an excellent source of information on what each division is doing.

These and many other available services should help to coordinate both the planning and the execution of research.

Regional research is now in position to respond quickly to emergency needs with the aid of two special funds . . . your central research fund, established on recommendation of the Committee of Nine, and the contingency research funds of ARS, which is now in its third year.

When the cereal leaf beetle was first found in the north-central region last year, the States and ARS lost no time in getting both control measures and research under way to halt its spread. In some parts of Europe, this pest of grains sometimes destroys half the crop. We don't want to see what it might do if it reached major grain-growing regions of the United States.

Regional research can look back on many fine accomplishments. The fact that it is impossible to single out any one of them as the finest, the most far-reaching, the greatest achievement proves their wide impact on our diverse agriculture.

If Dr. John L. Creech, one of our most enthusiastic plant explorers, were here in my place, he would name the introduction and evaluation of new crops and plants as the greatest achievement of cooperative regional research. Certainly, before the regional introduction stations existed, our means of providing new germ plasm equally to all the research people who could use it were rather limited. And without the impetus given by the regional approach to evaluation, new crops -- such as crambe -- would be developed for industrial use very slowly.

The fruits and ornamentals Dr. Creech and his colleague, Dr. Scott, obtained on their recent trip to Russia are the first plant collections we have been able to make there since 1929. Breeding stocks of these plants will of course be directed through the four regional stations.

In the future, regional research will probably reach beyond agriculture more and more, cutting across organizational structures into many disciplines that explore man's total environment. Research may be stepped up in the behavioral sciences, in which we are even further behind than in the natural sciences.

Through it all, let us never lose sight of the fact that we serve three groups of people -- scientists, agricultural workers, and consumers.

We must free the time of the scientists -- the scientists of today and the scientists of tomorrow -- so that they can devote their best energies to creative work.

Their discoveries must be relayed to those who can make use of them -- the farmers and other workers in agriculture and its industries. Research emphasis must shift with the needs of these workers. Though research serves big and little farms alike, that which will most benefit small farms and depressed rural areas is today being put to intensive use. And as more and more farms and ranches become outdoor playgrounds for cooped-up city dwellers, research must cope with new problems that the recreational uses of our soil and water raise.

Today, we are stepping up our efforts to make consumers realize what has always been true -- that they are the prime beneficiaries of agricultural research. Its pace must accelerate if we are to produce the food, the fiber, the oils, and the other agricultural products that the world's mounting populations will require.

Regional research, the meeting ground, can clarify and unify our task of serving all people. We must not disperse our energies or our funds in too many directions. Every fragment of investigation must bring some broad and pressing problem one step nearer solution.

As Federal services and State experiment stations join strength with strength, regional research can look forward to simplified and concerted attacks on the many problems that face American agriculture in the future.



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Last summer, at Logan, Utah, my old friend George Clyde, scientist, administrator, and now Governor of Utah, made an outstanding speech to the Soil Conservation Society of America. As he finished, almost as an afterthought, he said:

We are facing today a challenge, the like of which has never been experienced by any people before, because the world today is divided into two camps, with two different ideologies, separate and distinct, and completely opposite.

One stands for the preservation of freedom and our heritage as a free people, the other stands for regimentation and control by force. In the brief span of 40 years, the second ideology has conquered a third of the world's peoples, and you can add another third through their satellites; the remaining third is under siege. We talk about these resources of ours, which are absolutely essential, but without our freedom and without the preservation of our heritage, we have nothing.

Let us start from this point, set by Governor Clyde. Without our freedom, and without the preservation of our heritage, we have nothing. Now, what does this mean to us? I think it means simply this: There has never been a time when the conservation of our natural resources has been of greater importance than it is now. We are standing at a point in time, at a place in the history of the world, when the very wisest possible use of our natural resources for the benefit of the whole free world is basic to the survival of human freedom--and on this depends the future of mankind on this earth.

You and I, and all the other millions of people who form the great soil and water conservation movement in this country, are working to preserve and improve our most basic and primary heritage. All the things America stands for depend on this effort, and all our hopes for improving the lot of the people in underdeveloped countries depend on it as well.

Can a free people democratically organized and cooperating, as we are doing in conservation districts, accomplish this great task?

It seems to me that while we may take great pride in our accomplishments thus far, nevertheless we need to face some . . . difficult facts.

We are a little better than a third of the way toward the complete conservation of our soil and water resources in this country. We can measure this in terms of the physical job--acres surveyed, acres planned, acres of land properly treated, acres and miles of this or that conservation practice--but there is much more, of course, to the conservation movement than these physical facts having to do with land and water.

There is the tremendous response of innumerable informed people and organizations, offering to help, and actually contributing substantially to the movement. How can we measure this? Specialists in national advertising, skilled in the promotion of products, have said that they have never seen an idea with the impact of soil and water conservation on the American public. In fact, they said this several years or more ago. But what now, as our people concentrate in metropolitan areas? Are these people well informed? Do they understand the relation between our soils and our future? Between our resources and freedom? Do they see the needs we must yet satisfy? Will they help? Who will show them? They do not live in close association with the land--only with the products of it, which are not only bountiful but presently super-abundant. How can these millions of Americans see that present bounty cannot last without attention to the land that produces it?

We must note that only 37 years from now we will probably have in this country of ours nearly twice as many people as we have now, enjoying prosperity greater than that of any other people in the world, and with 70 percent of us living in urban areas. All this, they tell us, is likely to be accompanied by a shorter work week, higher incomes, and more leisure activities.

How will the soil and water conservation job expand? It has taken almost 30 years to get the first third of the work done. At this rate, it might take 60 years to complete the

remaining two-thirds. But to keep up with the population increase, we need to consider seriously how we may double the rate at which we go forward if we hope to come out about even in the year 2,000.

I am not here to make projections, but to look ahead. It seems likely that within 37 years the demands on our resources will have expanded enormously, not only, I suggest, from a doubled population of Americans with their greatly multiplied demands, but also by the world's hungry, underfed, undernourished, starving populations estimated even now at some 3 to 4 billions of people.

In this world in which we live we are told that 4 children are born every second, 240 a minute, 300,000 a day. The population experts believe that by the end of this century Asia, for example, will have a population greater than the entire population of the world at the present time. How are these people going to be fed? What part will our country play, what part must it play, in helping prevent the starvation, the malnutrition, of the unfortunates of our world?

From every sign we see, from the weight of overwhelming fact, it is crystal clear as we look to the future that we must increase our rate of progress in conserving our land and water resources. We need to develop new concepts, to enlarge our perspective, lift our horizons, improve our planning, and seek constantly to perceive more correctly. Your President during the last year, Bill Carter, saw this clearly, and he hit the idea hard, many times:

"During their 25 years of existence," he said, "our Districts have carried out a wide variety of conservation practices. Many worthwhile projects have been completed.... Each District prepared a program . . . when it was organized. But now the time has come to take a hard look-see at this program . . . there is a very serious need for all Districts to develop up-to-date programs . . . ."

"Originally," he went on, "we were interested mainly in erosion control and soil conservation; but now we are concerned with the full range of rural community development; with the use and conservation of our soil and water; with recreation, wildlife, and

urbanization; and with many other problems . . . . "This new, long-range plan for our Districts is Number One on my list . . . as President . . . during the coming year."

And your national President, Marion Monk, declared at your last State meeting, "We are headed into a new type of agriculture --a new type of rural America, one vastly different from any we have worked with before . . . . If (we) do not begin to prepare for this change . . . we will have failed in our conservation job."

What are the opportunities ahead, for the Soil and Water Conservation Districts of New Mexico?

Well, 15 districts have up-dated their programs and 13 signed modernized versions of their memoranda of understanding with the Department of Agriculture plus one with the Department of Interior. In these districts, we might say that the decks have been cleared for action. They are now in a position, it would seem to me, to begin moving toward such things as (1) greater participation of all landowners and operators in their programs; (2) stronger efforts with respect to conservation planning; (3) increased rates of application of conservation measures; (4) new ways of adjusting land use to include income-producing recreational projects and enterprises of greater variety; (5) multiple developments in small watershed projects; (6) improving the income of their people and eliminating under-employment; (7) expanding job opportunities; (8) improving existing community facilities and institutions, or building new ones so that they may assure pure water supplies, first-rate schools and hospitals, and all the other services that are standard in a modern community.

These are many among the goals set forth in the Department of Agriculture's Rural Areas Development Program. In any district, to achieve them will take a tremendous lot of doing. But only the local people in a soil and water conservation district can make such a program a reality. The Department of Agriculture through its many agencies can help technically and financially, but the initiative must come from the local people. They must furnish the drive and the leadership.

The 15 districts in New Mexico that have modernized their programs have taken a key action. In company with Bill Cater and Marion Monk, I would urge the remaining 41 to make a similar step the prime objective of this coming year.

There is a wide variety now, of new tools available to districts to help them go forward. Combined with the tools we already have, districts can now realize their hopes for development and growth, for better living, for making the holdings within their boundaries better placed to live on, and for increasing their prosperity.

I should like to mention some of these new tools that are now available for use:

1. Under the new Cropland Conversion Program farmers can shift from producing crops in over-supply, to grass, trees, wildlife, and recreational uses. This program is under way on a pilot basis in 237 counties in various parts of the United States. In addition to sharing the cost of materials and assistance needed for conservation measures, the Department offers adjustment payments to help maintain an adequate income during the transition from cropping to other uses. Long-term agreements will be based on a basic conservation plan. You will recognize in this an application of the principles used in the Great Plains Conservation Program. Once this program has been worked out, we hope to see it given wide application where it fits.

2. Next, it should soon be possible, we hope to begin the Rural Conservation and Development Projects. These, I'm sure you know, were authorized by our Congress last year; there remains the matter of the passage of the appropriation act under which the government can finance its part of the projects.

We believe this program has a great potential, and we have been very glad to see the application from the Northern Rio Grande Project here in New Mexico. This project appears entirely sound in conception. My Administrator, Don Williams, tells me he is very hopeful about the project, and that in his opinion it appears to have a good chance of getting somewhere.

3. A closely associated program provides for the development of Rural Renewal Projects--comparable to urban renewal work. These projects are to be set up in rural

areas that are "severely disadvantaged," where much of the land is not in its best use, and as a result, where chronic underemployment and underdeveloped communities dominate in the area.

4. We come next to the possible developments in the field of recreation, which I suggest, should be of very great interest in New Mexico. For one thing, the small watersheds act was amended to include cost-sharing on public recreational development, as well as to allow for municipal and industrial water storage in detention reservoirs. In Washington we are receiving numerous proposals from local organizations to add public recreation to watershed projects, and we believe this trend will increase rapidly. After all, under this new amendment, local sponsors can now get recreational developments on a watershed project reservoir for half the cost--the government will advance the rest. This goes for land costs, and for costs of developing recreational areas, including enlargement of the reservoir capacity, access roads and trails, picnic areas, campsites, and various other facilities.

5. At the same time, farmers and ranchers in soil and water conservation districts can now get technical assistance from the Soil Conservation Service in establishing income-producing enterprises on their lands. Congress, as I believe most people are now aware, has formally recognized recreation, for the first time, as an agricultural land use.

Recreation includes a great many things that people like to do in their vacation time--vacation farms or dude ranches, picnic areas, fishing, boating, swimming, hunting, camping, bird-watching, and so on. Technical help on such ventures comes from the SCS; ASCS will cost-share on certain practices, and FHA will make loans as well.

In illustration of the way this work is going, let me mention findings of a recent survey we made, covering the last fiscal year. This showed that one or more income-producing recreation enterprises were established on the lands of 9,800 district cooperators. Another 9,000 announced their intention of doing the same thing. Included in these developments were 945 cooperators who actually changed over from livestock, dairy, crops, fruit or other "regular" farming or ranching activities, to recreation enterprises as a primary

source of income. This involved almost 238,000 acres of land.

I might add that while no one thinks recreational facilities on farm lands are a solution to all farm problems, nevertheless they can provide a welcome and important addition to landowner and community income.

Let me say at this point that in terms of opportunities for the development of both public and private recreational areas and enterprises, New Mexico unquestionably stands among the foremost of all the States in our nation. Few States can rival New Mexico in its natural advantages. You have many congenial climates, magnificent landscapes, scenic mountains with fine forests intermixed with beautiful valleys, many interesting kinds of wildlife and something Easterners especially appreciate--wide, open spaces. Let me urge you to capitalize on the abundance and variety you are blessed with.

I was very glad to learn on my arrival here, by the way, that about 100 farmers and ranchers in New Mexico have developed recreational enterprises on their lands this past year and a half, and some of them have secured FHA loans to help them. Among these enterprises are 10 that are concerned with trout-fishing, 6 with horseback-riding, 3 with camping areas (and quite a few more of these are in the making), 10 with deer and antelope hunting, 4 with summer cottages, one with a nature trail, and 3 with elk hunting. One of these elk hunting enterprises, incidentally, grossed about \$150,000 this last year.

I have also been interested to learn about the cigarette tax here in New Mexico, the returns from which are used for recreational purposes. I must admit I know of nothing exactly like this elsewhere, but unique or not, it indicates planning for resource development in this State that is out of the ordinary.

In the light of these highly interesting and significant developments in New Mexico, I want to rephrase a sentence I used a moment ago when I urged you to "capitalize on the abundance and variety you are blessed with." I'd like to change that to read instead, "Let me urge you to continue and increase the excellent work you have already begun in capitalizing on the abundance and variety you are blessed with!"

And now a final note:

Presently there are nearly 3,000 soil and water conservation districts in the United States, and 56 of these are here in New Mexico. Every one of these is an active living demonstration of the fact that democracy can and does work. Every one of them exemplifies the belief of all Americans that freedom is essential to the fullest expression of human intelligence. Every one of them is proof of the fact that people and governments and organizations of all kinds and at every level in America can work together for the benefit of each of us and all of us. Over and above the magnificent job done already with our lands and waters, the soil and water conservation districts provide a unique and overwhelming demonstration to the whole world that freedom, and liberty, and the dignity of the individual are not only powerful concepts but are likewise the most practical and substantial and concrete forces for improving human well-being that have ever been devised anywhere in the world. And gradually the world's peoples are coming to learn this.

And this leads me to close with a brief quotation from a speech delivered three months ago in New York City at an international Congress, by that distinguished world citizen, Professor Charles H. Malik, former President of the General Assembly, the Security Council, and the Economic and Social Council of our United Nations.

Dr. Malik said: "What is most needed by the free world is how to make the values of freedom understandable and real, how to propagandize man, freedom, truth and the spirit, how to make this message of freedom distinctive and powerful and convincing.

"The greatest need is to fill the concept of freedom with meaning and content, to save it from hollowness and hypocrisy, from being confounded with other messages hailing from other quarters and having nothing in common with man, truth, freedom and the authentic spirit. But, he said, "you can convince nobody unless you are convinced yourselves, and you can propagandize nothing in which you do not originally believe. Without this living faith in the highest and deepest values of the 4,000 years of Western civilization, all your techniques and all your perfections will ultimately only play into the hands of your enemies."

May I say that if we are able to proceed with the successes that districts have achieved so far, with the vigor and enthusiasm that finds its greatest possible exemplification in the soil and water conservation movement of the United States, we can face our future with the confidence that comes from accomplishments.



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Recreation and Small Watershed Projects 1/

As we look briefly at recreation in relation to watershed projects this evening, I believe there are two assumptions we ought to mention, even though all of us are quite familiar with them:

The first of these is that our population is increasing rapidly and is variously estimated to reach some 261 million by 1980 or perhaps double what it is now by the year 2,000. The second is that demands by this population for outdoor recreation are quite likely to be 2-4 times as great in 1980 as in 1960, and very much greater than that by 2,000.

On the basis of these assumptions, which are generally accepted as reasonable, we may expect that a constantly increasing amount of activity will take place aimed at enhancing recreational opportunities for the American people. One group of these activities will undoubtedly surround the small watershed projects. This will be so because, as many people have noted, water is a magnet. It catches the interest of the public and it draws the biggest crowds. It is a place where people like to play.

All of us, I believe, are well aware that a new law (P. L. 87-703, approved September 27, 1962) adds some things to the Watershed Protection and Flood Prevention Act, known familiarly to many of us as P. L. 566. These same things apply, incidentally, to the 11 authorized flood control projects. The general direction in which the new legislation leads us is toward multiple purpose use of reservoirs. The amendments we are interested in tonight are these:

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1/ Prepared by William R. Van Dersal for presentation at the Annual Meeting of the Oklahoma Chapter of the Soil Conservation Society of America, Altus, Oklahoma, November 9, 1962.

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1. The recreational benefits that are expected to result from the use of watershed project facilities may now be evaluated in monetary terms and used in determining the economic feasibility of the project as a whole. For this purpose, recreation is defined simply as the enjoyment of all forms of outdoor recreation that involve bodies of water developed or improved as a part of a watershed project. This includes public fishing and hunting.

2. In a watershed project the Federal Government can now share with local sponsors the cost of acquiring land, or easements, or rights-of-way that are needed either for fish and wildlife developments or for recreational developments. The cost-share limit is 50 percent. State fish, wildlife, and park agencies are eligible for such help, as are counties, municipalities, and special purpose districts--such as soil and water conservation districts--created by or under State legislation. We can say this in other words: A local organization authorized by State law to carry out, maintain and operate public recreation facilities or fish and wildlife developments can now get land or land rights for the facility at half price.

3. The government can share in the costs of constructing water resource improvements needed for recreation and for fish and wildlife purposes--up to half. In addition, the government can bear the full cost of the engineering and other services associated with the construction.

4. The government can share up to half the cost of developing the minimum basic facilities needed for public health, safety, access, and use of recreational developments. These need to appear in the plan for the watershed project.

It is worth noting here that these "minimum basic facilities" may involve quite an array of things that you might have to have in order to get to, or

to use a recreational area. These might include roads and trails, parking lots, public water supply, sanitary facilities, power facilities, beach development, docks and ramps for boats, picnic tables, fireplaces, campsites, and plantings along the shoreline or within the general area. Specifically excluded from this list are such things as lunch stands, cabins, motels, community buildings, dance halls, or boat houses. If the local sponsor has to hire engineering or architectural services to help with these "minimum basic facilities," the government can share half of that cost also.

5. Besides sharing the cost of public recreational developments, the government can share up to half the cost of providing minimum basic facilities needed for a development intended primarily for the preservation of fish and wildlife. In this kind of a development we are interested in the creation or improvement of habitat or environment for fish and wildlife and perhaps the preservation of rare species. Consequently, our facilities consist of the kinds of things you need to do in order to manage the area for fish and wildlife. They include plantings, fences and cattleguards to protect the area; and shelters, sheds, roads and trails necessary for fish and wildlife management. No fish hatcheries or rearing ponds are eligible, and neither are any facilities that would open up the area for public hunting or fishing.

6. Local sponsors can get loans at fairly low rates of interest for installing, repairing, or improving water storage facilities, and for providing minimum basic facilities either on a recreational development or a fish and wildlife development. By and large, whatever items of this kind are shown as essential in an approved watershed project plan, are eligible for loan.

Now, there are, of course, certain general policies and provisions surrounding the use of these new authorizations. For one thing, the

recreational developments must be available to the public. There must be at least one access road, and the entire immediate shoreline of a reservoir must be open to the public, that is, a private landowner cannot have exclusive use of any section of the shoreline. The number of recreational developments is limited to one for a watershed project of 75,000 acres or less; to two for a project 75 to 150 thousand acres in size; and to three for a project larger than 150,000 acres. This restriction applies to cost-sharing for land and land rights and to minimum basic facilities, but it doesn't apply to cost-sharing on water impoundments for recreation. It must be clear, too, that any recreational development meets a need that isn't satisfied by other water-based recreation areas existing within the same general area.

Single-purpose recreational facilities can be developed within watershed projects that involve flood prevention or agricultural water management, but watershed projects may not be developed for recreation alone. Going projects already authorized are eligible for federal financial assistance with recreational developments provided a construction contract has not already been executed for the specific structure involved.

There are various other ifs, buts, and whereases, and there are many sliding adjustments intended to make things better even if complicated. The net effect, however, is that recreation is now recognized in federal law as having the status and deserving the attention accorded all other major phases of watershed work. I have an idea that in Oklahoma as elsewhere, this development is welcome indeed.

There are some basic concepts or ideas that we need to keep in mind as we consider what might be done about recreational developments in watershed projects:

1. Outdoor recreation is necessarily based on land, water, air, or a combination of these. In watershed projects, recreational opportunities are based primarily on water, with due regard for associated shore areas.

You don't really have to have a watershed project in order to develop opportunities for such things as hiking, horseback riding, camping, picnicking, bird-watching, or even hay-rides--but all these are often considered more enjoyable if they are near areas of water.

But you do need a watershed project (or a natural lake or stream) if you want to develop recreational opportunities for fishing, swimming, water sports, waterfowl hunting or refuges, or for wintertime ice-skating out-of-doors, or for fishing through ice.

2. Our second thought is that recreation varies with people. Recreation needs, therefore, are determined by what people like to do, either as individuals or in groups. And before we go on past this idea too quickly, let us note that here, as with other things, "one man's meat is another man's poison." You may consider a lake to be a good place to fish, but others may not see it that way at all. They may look upon it as just the place for speed boats and water skis. Still others would have none of these; they see a lake as exactly the thing we need for a waterfowl refuge. The point need not be belabored.

Obviously many uses that may not be compatible must be taken into account in recreational developments. The factors involved do not necessarily lend themselves to a dollar-and-cents reckoning either; some are quite intangible, even if real to their sponsors.

3. Thirdly, we are well aware that most of our land and water resources, and our cleanest, clearest air, are in the country. Conversely, most of our users of these resources for recreation, are in towns and cities. Access, therefore, becomes of great importance. Access means not only roads to reach,

an area, but it also involves the distance people have to travel to get there. A correlative idea of considerable importance is that unlimited crowding reduces the quality of any outdoor recreational facility. It's not much fun fishing if you have to stand in line to get to the edge of the water. And it takes the edge off the pleasure of water-skiing if the lake is jammed with boats.

4. There are almost always more uses for stored water than for recreation alone. If you intend using the water for domestic purposes, you'll have to filter it if the lake is used for recreation. If the impoundment is intended to help prevent floods, or to supply irrigation water, then the water level is probably going to fluctuate. This isn't necessarily the best thing for fishing or boating, or even swimming. Conflicts between uses, and indeed, between different kinds of recreation must be resolved well in advance.

5. However lovely the lake and its environs may be, if it is open to the public, certain segments of the public will despoil it. Tin cans and trash, beer bottles and garbage are not unknown in Yellowstone or Yosemite; they are part and parcel of essentially every area used by any considerable number of people. This unfortunate fact need not deter us from developing public recreational areas, but let us plan to meet this problem too, as well as for better things.

6. For recreational purposes, there is more to a lake than simple impoundment. The water must be clean--that is, free of pollution and the wrong kind of bacteria. People persist in drowning despite all sorts of safeguards, and public liability insurance is a point that may not be neglected. Both in relation to this point as well as the preceding one concerning despoliation, it is clear that somebody has to be on hand to be sure that the public doesn't injure either the facility or itself.

All these things are obvious, but the obvious is often overlooked. I suggest that our great and commendable interest in fostering recreation not be permitted to stub its toe on a point so apparent that we forget all about it.

The part that my own organization, the U. S. Soil Conservation Service, will play in this new work is considerable. We have been studying and preparing for this development--if it should come to pass--for a long time. Altogether aside, however, from what we might call the "regular" technical assistance that we have rendered in watershed work, we are clear on several points. The first of these is that the Soil Conservation Service is not about to become a recreational agency. Our role, rather, is to continue land and water resource work taking recreation into due account simply as one, other, now clearly recognized major use for water and land.

We hope to approach this very real opportunity in an orderly way. Recreation enjoys great popularity in our country these days, and it would be a great pity if that popularity were to overcome better judgment. We cannot afford, we think, to follow a wildly swinging pendulum. We are determined to pursue a hard-headed, practical approach involving sober and careful consideration of recreation not as such, but as one way in which land and water resources can profitably be used.

It is well to note at this point that the Soil Conservation Society of America is taking an active interest in recreation. For example, we have a committee on Outdoor Recreation. At our last national meeting in Washington, an entire session was devoted to the problems and opportunities in this field. More recently the Society has reaffirmed its recreational policy in an official statement submitted to the Land and People Conference at New Orleans. The Society's position is:

1. To encourage outdoor recreation as an integral part of conservation farming.
2. To cooperate fully in nationwide promotion and development of outdoor recreation on private lands.
3. To support the principle of reducing over-abundance of crops through recreational use of private lands.
4. To support the Bureau of Outdoor Recreation in the Department of Interior, the U. S. Department of Agriculture, and other federal agencies in a program for development of outdoor recreation on private lands, and to work directly with State and Federal agencies in furthering outdoor recreation.

To carry on with this thought--the role to be played by various groups or individuals--let us note that in order to have a recreational development at all, somebody has to acquire the land, or the right to use it, around the reservoir concerned. A number of ways in which this can be done come readily to mind. Clubs, associations, and other organizations have already demonstrated that with a little forethought, such areas can become important public assets. I have visited a number of such projects developed for under-privileged children by civic groups, or for Boy Scout summer encampments, and I think these are excellent examples of public use. I hope we have more of them.

But I am thinking particularly of the part that can well be played by county, municipal, and State governments. We already have a few examples of this, but a great deal more needs to be done. Actually, leadership in the development of recreation in a State should be taken by the appropriate segment of the government of that State. The report of the Outdoor Recreation Resources Review Commission--familiarily known as the ORRRC report--makes this point (p. 169):

"All levels of government share an interest in and responsibility for meeting the outdoor recreation needs of the Nation. There will be continuing need for cooperation and joint action among all jurisdictions. However,

the State governments have dominant public responsibility and should play the pivotal role. Accordingly, it is extremely important to stimulate State activity." (Underscoring supplied.)

The same report notes that "Federal aid cannot provide more than a fraction of the funds needed, nor should it; its great importance will be as a catalyst to spur local and State action. The State governments are in the key position. They have a variety of agencies that deal directly with recreation . . . . So far, there has not been much statewide planning to bring these efforts together; but there is a growing recognition of the need for it."

Echoing this ORRRC report, it is safe to say that recreational developments resulting from watershed project installations so far have been largely sporadic. What we ought to have is close, regular participation of State recreational agencies in the very earliest stages of watershed planning. As a major aspect of the State agency operation, these watershed projects should be incorporated in a State system of recreational developments intended to open the outdoors to all the people in the State in a thoughtfully planned way. Each watershed project, as it begins to develop in the thinking of a local sponsoring group deserves prompt and careful attention by the State agency responsible for recreational development--in the fullest and largest sense--in the State. And, if there is presently no State agency with such clear responsibility, it would be well if one could be designated either by executive or legislative action as might be required.

Let me note here some of the excellent developments in Oklahoma. I cannot mention them all, but I know about a few of them. It is noteworthy that the cities of Duncan, Marlow, and Weatherford have promoted recreational developments on Wild Horse, Rush, and Cobb Creeks. Your Fish and Game Commission has participated importantly in the developments on Dead Indian Wildhorse,

Big Wewaka, and Caney Coon Creeks. In the latter, the City of Colgate has also played a part. These are fine developments, and there are a great many others that place Oklahoma among the early leaders in taking advantage of these recreational opportunities.

At this point I would like to acknowledge the key role of the soil and water conservation districts of the country in watershed project development. By and large they are the sponsoring or co-sponsoring organization, and as such, exert a tremendous influence on the watershed activities of the Nation. With respect to recreation, the districts are in the same coordinating or integrating position they have always been in with respect to other important phases of land or water use. They can enlist the assistance of any or all agencies, State, Federal, or local, and help direct technical and other competence to its maximum usefulness in a watershed project. There are many examples of the effective and valuable efforts of districts already known, and I am quite sure they will continue on a suitably stepped-up scale.

Actually, recreational developments provide an additional avenue for channeling efforts of more groups and agencies into the broad soil and water conservation program. I suspect the districts will make many more friends with this relatively new avenue, and that it will result in still greater support from the public for the outstanding work being performed by the soil and water conservation districts of our country.

As we have reviewed the subject of recreation this evening, in relation to watershed projects, we have alluded several times to the need for good advance planning. And this we must have if we are to meet the many problems posed by even the simplest recreational development. There must be study of the total area to be served, the number of people who may use it, and the access roads. The acquiring of the land or land rights takes study on many

scores--financial and legal, as well as others. The facilities to make the area as useful as possible take sober thought. It takes a lot more money than most people realize to set up a picnic table. The table itself is only a start; there must be a road or trail to it, arrangements for garbage disposal nearby, water needed by the picnic party, sanitary facilities that must go with it, the fireplace, and so on. Actually any apparently simple facility calls for all sorts of supplementary and complementary facilities that have to be planned on, or our original facility may not serve. The financing and operation and maintenance of all this takes considerable study and calls for the wisest judgment.

In conclusion, I should like to mention that our new federal legislation has supplied a missing link in the chain of cooperative activity we may now rely upon to open new vistas of sound land and water use. It is now possible for urban and rural people to work together for their common enjoyment. We have opportunities now, clearly foreseen by many people, to relieve the excessive crowding of many of our federal and State recreational lands. As the ORRRC report noted, "The broad scope of the small watershed program places it in a particularly favorable position to contribute to public recreation opportunities."

As the recreational developments are accelerated, so that they are brought within reasonable distance and cost to the average citizen, let us note finally that what all this adds up to is that America is going to be a better place in which to live.

The first part of the paper is devoted to a general discussion of the problem of the origin of life. It is shown that the problem is not only a scientific one, but also a philosophical one. The scientific aspect of the problem is concerned with the question of how life arose from non-life. The philosophical aspect is concerned with the question of whether life is a necessary part of the universe or whether it is a mere accident.

The second part of the paper is devoted to a discussion of the various theories of the origin of life. These theories are divided into two main groups: the theory of spontaneous generation and the theory of biogenesis. The theory of spontaneous generation is the older of the two and is based on the idea that life can arise from non-life. The theory of biogenesis is the newer of the two and is based on the idea that life can only arise from pre-existing life.

The third part of the paper is devoted to a discussion of the evidence for and against the various theories of the origin of life. It is shown that the evidence for spontaneous generation is weak, while the evidence for biogenesis is strong. It is also shown that the evidence for the theory of evolution is strong, while the evidence for the theory of creation is weak.

The fourth part of the paper is devoted to a discussion of the implications of the various theories of the origin of life. It is shown that the theory of spontaneous generation implies that life is a necessary part of the universe, while the theory of biogenesis implies that life is a mere accident. It is also shown that the theory of evolution implies that life is a result of natural selection, while the theory of creation implies that life is a result of divine intervention.

The fifth part of the paper is devoted to a discussion of the future of the study of the origin of life. It is shown that the study of the origin of life is a very active field of research and that many new discoveries are being made. It is also shown that the study of the origin of life is a very important field of research and that it has many practical applications.

t.23, 1964

## A NEW LOOK AT RESEARCH ON PESTICIDES



Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, at the annual meeting of the American Institute of Chemical Engineers, Las Vegas, Nev., Sept. 23, 1964

I am happy to participate in this symposium on the current status of pesticides. I welcome the opportunity to talk about the Department of Agriculture's research on pest control . . . and to tell you about some of the new methods being developed.

Previous speakers have discussed the painstaking procedures used to insure the effectiveness and safety of pesticides in this country. And I would like to stress one important fact. This country has the most comprehensive laws and enforcement procedures in the world for insuring the safe use of agricultural chemicals.

We have a program of pesticide safety promulgated by the Federal and State Governments and made effective by the cooperation of industry and agriculture. It is founded so firmly in logic and facts -- and is so tempered with extra precaution to avoid or minimize hazards -- that there should be no need even to defend it.

I know you share our concern that the Nation's food supply remain adequate, wholesome, and safe. As previous speakers have indicated, pesticides -- like other elements that influence man's environment -- are a source of both real values and potential dangers.

On the value side, more effective pesticides, and more knowledgeable use of them, have been key factors in the revolution in American farming methods since 1940. This revolution, based chiefly on technological progress, has increased total farm output by 60 percent.

The place pesticides occupy in modern agriculture is perhaps most clearly understood by considering the consequences if farmers had no pesticides. The eastern potato crop, for example, would be nearly a complete failure in years when moist, cool weather favored late blight disease. We would face total loss of citrus and peach production if the Mediterranean fruit fly should invade continental United States, as it has four times since 1929. And cattle production might easily be cut in half if tick-borne Texas fever should gain entry.

It is not enough to assure the public -- as we can -- that our food and drinking water are now safe . . . that airborne pesticides do not constitute a community-wide health problem . . . that scientists know of no instance where a registered pesticide has been implicated as a cause of human cancer . . . that the wildlife population is actually increasing, in many instances, despite widespread pesticide use.

Efforts must be continued to improve pest-control procedures so questions about their safety cannot be raised.

Our research assignment is clear. We must develop pesticides and application methods that completely avoid or drastically reduce the chance of environmental contamination. And we must find effective alternatives to pesticides. The Department of Agriculture has intensified its efforts in both directions.

We are convinced that pesticides will continue to have an important place in American agriculture in the foreseeable future.

Ideally, a small quantity of an insecticide should be sufficient to control the target insect without destroying its natural enemies. The insecticide should persist just long enough to control or eradicate the pest -- and the effective duration may be minutes for a space spray against flies, or days, weeks, or even months for a soil treatment to control emerging insect larvae. Once the pesticide has done its job, it should readily decompose into products that are harmless to the environment.

Pesticides that approach this ideal are on the market, and their number is growing.

An example is the improved formulation of the insecticide malathion used by Federal and State workers in cooperative grasshopper control last summer. They needed only 8 to 10 ounces per acre, instead of one gallon per acre required with older malathion formulations.

The insecticide TEPP is an example of a material that offers little danger to the environment. It is completely decomposed, in the presence of moisture, to harmless water-soluble products in 48 to 72 hours. In contrast, inorganic insecticides such as lead arsenate may remain unchanged and toxic in the soil for many years.

Along with pesticides tailored to specific needs must go accurate application methods to avoid drifting of sprays or dusts onto adjacent land or water areas.

Department of Agriculture scientists have had considerable success increasing the uniformity of particle size in both sprays and dusts. Uniformity of particle size is the key to pinpointing pesticide application where we want it. With better control of the material, more effective insect-control results might be obtained with only a fraction of the pesticides now used.

Alternatives to airplane application likewise hold promise where they reduce the amount of pesticide drift outside the target area. Helicopters have been used to spray Christmas tree plantings, and our scientists are experimenting with large ground sprayers capable of covering 60 to 100 acres per hour.

It's often possible to accomplish the insect-control objective with a greatly reduced amount of insecticide by knowing the opportune moment to strike. Our basic studies of the life cycles of insects are helping us to time insecticide applications when the insects are most vulnerable.

In 1957 Louisiana entomologists discovered that some boll weevils enter a stage called diapause in the fall in preparation for hibernation. The weevils that enter diapause are the ones that emerge and multiply the following spring.

Fall spraying of cottonfields before frost should kill a high proportion of the diapausing weevils. Such action might reduce the number of sprayings the next year. Fall spraying has been highly effective in large-scale field experiments in the Presidio-El Paso Valley area of Texas.

Earlier, I indicated that the Department of Agriculture has intensified its research to find alternatives to conventional pesticides. This is no recent development. Nearly 10 years ago we recognized the necessity of reorienting our research to develop methods that could replace pesticides or be used in combination with pesticides.

Now, more than two-thirds of the Department's research effort is directed at developing biological and other highly selective ways of controlling pests and diseases -- along with basic studies relating to such methods. Much imaginative research has been done, and from it have come promising new approaches.

One is the use of sterile insects for the destruction of their kind.

Massive release of male screwworm flies, made sterile by exposure to gamma radiation, had spectacular success in ridding the Southeast of this costly livestock pest in 1958. The radiation treatment does not visibly alter the insects nor create an environmental hazard. But eggs laid by female flies in the native population do not hatch if these flies mate with sterilized males.

With the same technique, a Federal-State effort during the past 2½ years has reduced the incidence of screwworms by 99.9 percent in the control area of Texas and New Mexico. And it has completely prevented screwworm infestation in adjacent States. Losses to livestock were estimated at \$25 to \$100 million annually in the Southwest before this effort. In 1964 they probably will be nil in the area under control.

Our scientists believe that the radiation technique may be similarly effective against some of the major pests of cotton and fruit.

The integration of the sterility method with pesticides or other conventional ways of controlling insects is particularly promising. An effective insecticide or a rigid cultural control program may remove 95 percent of an insect population. But the remaining 5 percent will again build up to destructive numbers unless the treatments are applied regularly. Also, the amount of insecticide required and its cost are essentially the same, whether the insect population is high or low. However, we might annihilate or control that remaining 5 percent by releasing relatively few sterile insects.

We can also destroy the insect's ability to reproduce by using chemosterilants. We hope through further research to devise techniques for placing chemosterilants within reach of some of our important insects, which in effect will treat themselves.

Chemicals may have a practical advantage over radiation for sterilizing some insect species. And using chemicals for sterilizing insects in the native population has an inherent double effect. First, sterilizing a given portion of the pest population is equivalent to destroying that portion, so far as its reproductive potential is concerned. Second, as sterilized insects compete for mates, they reduce the reproductive potential of the remaining unexposed insects.

A practical way chemosterilants might be used would be in combination with an attractant. These may be a sex attractant, a feeding stimulant, or perhaps a special type of light.

The attractant approach to insect control offers many possibilities. We might draw the insects to a trap and destroy them. Or an attractive bait might be used to poison the insects with an insecticide or infect them with an insect pathogen. No pesticide may be needed -- or at least, the required amount might be very small -- and treatment of entire fields would be avoided.

Two methods have been used in finding attractant materials. One is to isolate and identify a natural substance -- and if possible to synthesize it. The other is to screen hundreds or thousands of chemicals synthesized in the laboratory.

An attractant, an insecticide, and the sterile-male technique were combined in experimental eradication of the melon fly from Rota, an isolated Pacific island. Protein hydrolyzate -- which triggers a feeding response and weakly attracts -- was combined with malathion insecticide to reduce the melon fly population. Then eradication was accomplished through mass release of male flies sterilized by gamma radiation.

An attractant was likewise used in the rapid eradication of the Mediterranean fruit fly from Florida in 1962. In this instance, a synthetic food lure drew flies to an insecticide bait. The fruit fly outbreak was controlled with only a fourth as much insecticide as would have been needed if the chemical alone had been used.

The research on attractants is beginning to unravel the mystery of why some pests concentrate their attacks on certain host plants. For example, we knew that the boll weevil shows little interest in any plant other than cotton. We have discovered that cotton plants contain two substances -- one that attracts boll weevils to the plants and another that encourages the weevils to eat.

We have much more to learn about attractants. Still to be explored are those natural attractants that induce the insect to lay its eggs. Perhaps we can trick it into depositing the eggs where they will not hatch.

Anyone who has left the porch light burning on a summer night knows that light attracts certain insects. We have routinely used light traps as survey tools, to determine the population of certain insects in an area. Now we are making a renewed effort to control insects with light. This approach is beginning to show promise, particularly against insects that fly long distances.

On an experimental basis, we trapped tobacco insects in an area of more than 100 square miles in North Carolina, with encouraging results, using near-ultraviolet light. We know that such light also lures certain cotton and cabbage insects, and that adult boll weevils are attracted to blue-green light.

Another possible substitute for pesticides is exploitation of the numerous pathogens that attack insects. Like other living things, insects are preyed upon by bacteria, fungi, protozoa, and viruses. Promising pathogens are under investigation for major pests of vegetables, corn, cotton, tobacco, citrus, and forest trees.

Pathogens have important advantages for pest control. Those that have been found useful are harmless to man, animals, plants, and natural enemies of insects, and leave no objectionable residues. The amount of a powdered virus that is required to treat five acres for corn earworm or cotton bollworm control is so small that it could be held on the nail of the little finger.

Many of you are probably familiar with milky spore disease for controlling Japanese beetles on lawns. Our scientists are now seeking a way to mass-produce the material economically so farmers can use it on grassland.

The viruses, fungi, and other pathogens that attack nematodes or eelworms, might be similarly used as living pesticides. Nematodes, serious pests of sugarbeets, tobacco, and other crops, are now controlled almost exclusively with chemicals.

An additional possibility for biological control of insects is genetic alteration. We might produce and release insects with inferior or lethal genetic characteristics that would be transmitted to succeeding generations and eventually destroy the insect race.

Entomologists are also exploring natural growth-regulating substances. For example, the insect juvenile hormones might be used for preventing the development of insects to the mature stage.

Various physical phenomena might be employed to control insects. Included are possible uses of various wavelengths of light, sound, and radio waves. We might, for instance, make practical use of our knowledge that hordes of male mosquitoes respond to a recording of the call of the female mosquito. Or we might use flashing lights to make insects develop into adults when they should be entering diapause in preparation for hibernation. Exposure of certain kinds of insect larvae to flashes of light lasting no more than 1/1000th of a second is known to upset their life cycle.

Genetic alteration, diseases, attractants, and sterilants are largely developments of the past decade. But the Department of Agriculture has used a biological approach since 1888. That was the year the first USDA entomologist went overseas to seek natural enemies of imported insects and weeds. Since then we have brought in more than 600 of these friendly predators and parasites.

Imported natural enemies have controlled or helped control some of our most destructive pests. But less than a fifth of the friendly imports have become established here. And those that survived transplanting seldom kept pest numbers below the point where they cause economic damage. So we feel that the use of natural enemies alone will not completely solve most insect problems.

Perennial weeds might also be combated by genetic alteration. Perhaps we can inhibit weed seed production or prevent pollen development in unwanted plants. Or we might hasten weed control by inducing all weeds to germinate at once. At present these are not much more than scientific concepts.

Another form of pest control -- and one that has been particularly effective in a number of instances -- is the breeding of plants resistant to diseases and insects. This is an almost ideal method, involving no extra cost to farmers and offering no environmental hazard. Its limitations are the time required to create a new variety -- often 10 years or longer -- and the lack of sources of resistance available to plant breeders.

Nevertheless, disease resistance has been incorporated into many crops where pesticides were once used. We have also produced some insect-resistant plants. Most notable are 17 varieties of wheat that withstand the scourge of the Hessian fly, an insect that once devastated our grain belt. So far, the mechanism for breeding disease and parasite resistance into livestock has eluded us.

Not to be overlooked in our search for new pest-control procedures are cultural and management practices that reduce the necessity for pesticides. Most farmers use such measures as crop rotation, plowing under and burning stubble, destruction of insect breeding places, and adjustment of planting and harvesting dates to minimize pest damage.

Similarly, dairy management practices that eliminate the disease mastitis avoid the need for chemicals that might contaminate milk. And strict sanitary measures in the hog lot and poultry house often keep diseases in check without additional effort.

We are confident that research will continue to add to our arsenal of management practices. Recently, for instance, our scientists demonstrated that the swine kidneyworm, a parasite of hogs, can be eliminated from swine breeding herds if farmers follow three recommendations: Use only gilts for breeding, market the gilts when their pigs are weaned, and eliminate all older hogs from the area where pigs are raised. This parasite causes losses of more than \$72 million annually in the Southeastern States.

Finally, we are constantly guarding against the importation of new pests through continuous and careful scrutiny of everything that enters our country from abroad. If some pest slips through this protective quarantine, we have the facilities for rapidly detecting and eradicating such unwanted immigrants.

From my discussion, it is evident that we have a variety of pest-control methods at our disposal.

And no single type of control is likely to give general protection. A variety of special-purpose weapons and methods is needed to combat destructive insects, plant diseases, weeds, and nematodes. And the search for new pest-control techniques is developing new materials -- such as attractants, pathogens, and chemosterilants -- that one day may be mass-produced by the chemical industry.

While pesticides are presently our most important and economical weapons, the number of effective alternates is growing. More and more, the pest fighters of the future will employ a combination of methods.

They may reduce the insect population by luring the pests to an improved pesticide, or by using natural enemies or physical means. Then they may complete the kill with sterilization, a pathogen, or genetic alteration. And they will avoid the necessity of control measures wherever possible by using inbred resistance and management practices.

We anticipate steady improvement in the effectiveness of pest-control techniques. Equally important, control and eradication will be carried out in ways that safeguard the consumer and protect the environment.

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RESEARCH -- A KEY TO THE FUTURE

Talk by Dr. H. A. Rodenhiser, Deputy Administrator, Agricultural Research Service, U. S. Department of Agriculture, at the 19th annual meeting of the Soil Conservation Society of America, Jackson, Miss., August 26, 1964.

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It is a pleasure to take part in this symposium on soil and water conservation research. We of the Agricultural Research Service always welcome the opportunity to participate in your meetings.

Your Society is an effective spokesman for those who realize the necessity of safeguarding and wisely using our natural resources. And your Journal has long been an effective means of disseminating our research results to those who want and need them. You are to be congratulated for your insistence on sound research principles as the basis for establishing conservation programs and policies.

Let us consider how research can open the way for more effective conservation practices. But, before doing this we should establish a common understanding of what agricultural research really is. You can help us destroy a misconception -- shared by too many people -- that agricultural research consists of field plots, fertilizer trials, and how to feed pigs for faster gains. You can help us explain that the agricultural scientist digs as deeply into the unknown and unexplored as scientists in oceanography, electronics, or space research.

The field plots and feeding trials are but important final steps in a much deeper and more complex effort. The crop varieties in the plots are likely to be the results of many years' detailed work -- an effort drawing upon knowledge assembled from many scientific disciplines.

The long-term nature of research investigation requires a shaping of its direction and emphasis, in anticipation of conditions that may exist 25 or even 50 years hence.

Several facts appear certain as we look to the future:

Our national population is rising at the rate of 340 persons per hour, 8,000 per day, 3 million per year. By the year 2010 -- less than 50 years from now -- we may have around 424 million people in this country.

Farmers will need to more than double their present output of crops and livestock products if our people are to be as well fed as they should be 50 years from now.

Consumers of the future will be more knowledgeable about nutritional needs, particularly the requirements of the old and the young. Homemakers will insist that food quality be uniformly high.

The amount of farmland available for production of food and fiber is not likely to increase much beyond the acreage farmers are using today. Some new land can be brought into production, but some of our present farmland will go into urban and other nonagricultural uses. Our farms will continue to increase in size and decrease in number.

The demand for water is growing even faster than the population. By 1980 we will require an estimated 600 billion gallons of water per day for all purposes -- almost twice present consumption.

In summary, we will need more than twice as much food to satisfy the requirements of a population that may rise 125 percent in 50 years. Yet, agriculture will have only about the present land acreage, and less water. These demands can be met only by intensifying our research on a broad front.

Farmers will have to improve their management of soil and water. They will need superior strains of crops and livestock to meet the demands of consumers and the requirements of processors and distributors. They will demand machines and tools that do a better job with less labor. They will require low-cost, effective ways of controlling diseases, pests, and weeds.

Fortunately, we have a research system competent to meet the challenge of the future. Federal and State scientists effectively cooperate, each undertaking part of the task. It works this way:

The State experiment stations are free to investigate any problem of interest to the people of their States. On matters of regional or national interest, they usually join with other States and USDA. The Department directs most of its efforts toward broad problems, many of which demand a national approach. These efforts are carefully coordinated to avoid duplication.

In the field of soil and water research, we have further formal and informal cooperation. The Agricultural Research Service directs much of its research toward needs encountered by the Soil Conservation Service, the action agency for applying conservation measures on the land. We also work closely, on matters of mutual interest, with the Corps of Engineers, the Geological Survey, the Bureau of Reclamation, other Federal and State agencies, and with private industry.

A major problem now demanding the attention of everyone engaged in agricultural research is how to improve the efficiency of American agriculture. It is a formidable task, considering the high level of efficiency already attained.

Efficiency improvement through soil and water conservation research takes many forms. The ultimate goals are less labor and expense for the farmer, and use of resources in a manner that assures their sustained productive capability.

For example, planting corn or potatoes directly in grain stubble would eliminate several expensive farming operations. Automating the application of irrigation water would free the farmer to do other urgent tasks, such as haying or timely cultivation. Mechanizing lined mole drain installation should reduce costs so more farmers could afford drainage. Economical methods of removing mesquite and sagebrush would improve the carrying capacity of western livestock ranges.

Here in the South, we are looking for better ways to get rid of excess water that interferes with farming operations. And we are making progress. Research in Louisiana, for instance, shows that we can reduce the cost of maintaining drainage systems in sugarcane fields by more than \$5 per acre thru precision land forming and smoothing and use of improved design of ditches. The improved drainage also eliminates shallow surface depressions that bog down harvest machinery.

Some areas of the South also suffer from too little water -- even though rainfall averages around 40 inches a year. Crops are damaged during short droughts that occur every year. We can minimize this damage by improving the capacity of the soil to store moisture, by developing crop varieties that tolerate these rainless periods, and by supplemental irrigation.

Throughout the country, another current research need is basic information. Improvement of many conservation practices is limited by our inability to answer three questions: What is happening? How does it occur? And why?

For example, stubble-mulch tillage -- an excellent method of restricting erosion on the Great Plains -- has a shortcoming. Grain yields on stubble-mulched land are sometimes disappointing in seasons of above-normal precipitation. Before we can correct this deficiency, we must know what takes place when straw decomposes in the topsoil. How does it affect the physical, chemical, and microbiological environment? Once we know, we probably can pinpoint the reasons for yield reduction and devise corrective measures.

Similarly, knowing the physics of water movement through soil is a prerequisite for improving irrigation practices. Or an understanding of protein synthesis by the cell is the starting point for solving those nutritional disorders of livestock that are related to crops grown on certain soils.

Nor do we need basic information only for solving current problems. We must press forward in our exploration of the unknown, building a fund of knowledge to draw upon in meeting the challenges of the future.

Numerous situations demanding research answers are already developing. One is the dearth of physical data on land and water resources because of shortcomings in our procedures for gathering this information.

We lack, for instance, accurate methods of measuring the wide variations in rainfall that often occur over relatively short distances. A striking example of this deficiency was noted in the summer of 1960, when a small convection storm crossed the experimental watershed at Tombstone, Ariz. Water was measured in a previously dry streambed, but all of the 60 raingages on the watershed were empty -- including those no more than a mile from the stream. If we can't measure precipitation accurately, our runoff estimates will have limited usefulness.

Measurements of sediment in streams will leave much to be desired until we can develop automatic equipment that would keep continuous sediment discharge records. And we cannot now measure the effects of vegetative cover, cropping methods, and conservation practices on runoff and sediment production with the precision we would like.

The Department of Agriculture, working jointly with other Federal agencies, is committed to the task of planning for the full and effective water resource development of the 18 major river basins by 1970. Computerized programs of analysis are available for the planning job outlined in Senate Document 97 of the 87th Congress, with which many of you are familiar. Right now, we don't have enough of the right data to feed into the computers.

A report of the Senate Select Committee on National Water Resources emphasizes the enormity of the task ahead. This report estimates the total requirements for capital investment in water resources at approximately 228 billion dollars, between 1958 and 1980. Thus, the cost of needed water resources development in the next 15 years is more than we are spending for the Federal highway program. Obviously, we must greatly expand our research effort -- to make sure our planning of these facilities is on a scientifically sound basis.

Another matter of growing concern is how to meet food production needs as the agricultural water supply shrinks. Expanding cities and industries in the West are already pressing claims for more water, and the trend will continue. Under a system of alternative water values competition will force agriculture to make better use of the water it has.

Reducing evapotranspiration from our vegetated lands is a particularly challenging way, since 70 percent of our precipitation passes into the atmosphere from soil, water, and plant surfaces. Perhaps we can devise physical or chemical means of reducing evaporation from the soil. Possibly we can treat plants with chemicals -- or alter them genetically -- to restrict transpiration.

Collecting and using water that otherwise would be lost as runoff is another possibility. In arid areas, we are covering unproductive hillsides with impervious materials and harvesting the runoff. Already, the procedure is feasible as a source of livestock water, and eventually it may be used to develop additional water supplies for municipalities, industry, agriculture, and recreation.

In a similar manner, we can divert the runoff from a small watershed onto level areas used for feed and forage production in low-rainfall localities. Or we can make a  $\frac{1}{2}$ -inch shower as beneficial as a  $2\frac{1}{2}$ -inch rain by making impervious plastic-covered ridges between crop rows and concentrating the runoff near the plants.

We are also learning how to store runoff and drainage water in underground reservoirs. We are seeking tillage methods that increase the capacity of the soil to take up water. We are solving the difficulties inherent in using saline water for crops.

In these efforts, we are continually hindered by inadequate basic knowledge that must be obtained through research. Electricity -- but not water -- can be measured accurately to many decimal places. Present procedures for measuring and controlling the water-intake characteristics of the soil are not precise. We can't predict the future moisture requirements of a field, a farm, or a community.

A more accurate assessment of the maximum potential of our various soil resource regions is another developing research need. We have long advocated using land according to its capabilities. Now it is logical to think more about devoting land to its most productive use. We will have no alternative, as we approach the time when food and fiber output must be doubled to supply an expanding population.

We must also begin thinking about the role of conservation in developing and protecting recreation areas. More land undoubtedly will be devoted to pleasure sites as the population grows.

Water is nearly always the focal point around which a recreational development is centered. The water supply must be adequate and dependable, based on sound hydrologic design. The water must be free of sediment, and the pleasure area may require protection from flooding, as well as soil stabilization to prevent blowing dust.

Your program chairman requested that I devote some time to the problems of soil and water conservation research that are as yet unforeseen. That assignment probably exceeds the capabilities of my crystal ball. Perhaps, however, I can suggest the type of research assignment we might face in the future.

The National Science Foundation recently appointed a special commission to re-examine the possibility of weather modification. The feasibility of cloud seeding for increasing precipitation is highly controversial. But suppose it should become a general practice. We would have to revise much of the data on precipitation, runoff, and sediment yield used in designing flood-control and water-storage structures.

Farmers in the loess soil area of Nebraska are now making nine- and ten-foot cuts in leveling their land for irrigation. This suggests the interesting possibility of massive land reshaping to bring the loessal hills of Mississippi into high production. We can't predict what new soil and water management problems would arise in developing and farming this land.

The cost of removing salt from sea water is now far too great for us to consider the ocean as a source of irrigation water. Yet, there is a possibility that someday we could afford to desalt saline water and convey it throughout the arid West. Such a turn of events might bring irrigation to soils whose response to intensive cropping is unknown, and could create drainage problems we aren't prepared to cope with.

Let me emphasize that I have no evidence justifying present concern about any of these problems. Nevertheless, we can expect the future to bring equally difficult challenges. We must not become so engrossed in the present that we are unaware of developing future problems.

Virtually all of the Nation's annual water supply -- averaging about 4 3/4 billion acre-feet -- falls as precipitation upon lands under control of the agricultural community. The vegetative cover and condition of the land to a large degree determine whether this water will be used beneficially, wastefully dissipated, or allowed to become a destructive force.

Agriculture faces a tremendous challenge and a great opportunity in the current and increasing competition for water. Sound policy and program decisions for living within the limitations of our natural resources require accurate information that can be gotten only through research. Much of this research remains to be done.

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